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Obesity and sickness absence – Results from a longitudinal nationally representative sample

Running head: Obesity and sick leave days

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ABSTRACT

Objectives: The current study aimed at investigating the longitudinal association between obesity and sickness absence in women and men in Germany.

Methods: Data were derived from the German Socio-Economic Panel (GSOEP), which is a nationally representative, longitudinal study of private households in Germany. We draw on data from 2002 through 2012. Information on self-rated BMI has been collected every second wave since 2002. Sick leave days (total number of working days missed due to illness in the past calendar year) and sick from work for more than six weeks in the preceding 12 months (yes; no) were used as outcome measures. Fixed effects (FE) regression models were used. Gender differences were examined using interaction terms (sex x weight category).

Results: Controlling for several potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women (β=.24, p<.05), but not in men – with significant gender differences (sex x obesity, p<.01). Moreover, conditional FE logistic regressions showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95%-CI: 1.08-1.85), but not in men. Gender differences were significant (sex x overweight, p<.01).

Conclusions: Our findings stress the longitudinal association between excess weight and sick leave days as well as long-term absenteeism in women. Weight management strategies might also be beneficial to reduce sickness absence.

Keywords: long-term absenteeism; sick leave days; body-mass-index; excess weight; longitudinal studies

Strengths and limitations of this study

- Data came from a large nationally representative sample of German individuals.
- Panel regression models were used, diminishing the problem of unobserved heterogeneity.
- The self-rated BMI was used to classify obesity.
- Attrition bias might be rather small in the current study.

INTRODUCTION

Obesity remains a major health concern in Western societies [1]. Behind the Americas, Europe ranks second regarding the proportion of overweight or obese people, according to the WHO statistics. The share of men and women being 18 years and over having a body mass index (BMI) ≥ 25 kg/m² amounts to 59.1% and 44.7%, respectively, in the EU-28. For Germany, the prevalence of adult obesity (BMI ≥ 30 kg/m²) has been recently estimated to range between 16.5%-23.9% in women and 17.3%-23.3% in men.[2 3] Obesity and its related adverse health effects pose a considerable burden to the healthcare system because of both its direct costs incurred by increased health service utilization and indirect costs arising from reduced or lost workforce productivity.[4 5] Several studies found that indirect costs of overweight and obesity make up the majority (51%-59%) of total costs, thus exceeding direct costs.[6] Unsurprisingly, the impact of obesity on the workplace in terms of absence from work due to excess weight related illnesses or other factors continues to be of primary interest to health policy makers and employers.

The association between obesity and sickness absence has been well documented cross-sectionally. Studies found a tendency for obese individuals to have a higher number of sick leave events and also have longer spells of individual sick leave compared to their normal-weight counterparts.[4 7 8] As regards pre-obesity / overweight (25 kg/m² ≤ BMI < 30 kg/m²), inconsistent results have been reported in literature for the association with sickness absence. While some studies found evidence of an elevated risk of sick leave for pre-obese subject, others reported no significant association when compared to normal-weight subjects. However, in general, there tended to be a positive relationship between higher levels of BMI and sick leave, although available results pertaining to short-term spells were less clear, which may be due to discrepant definitions of short-term sick leave.[7-9] Findings further suggested gender differences regarding the association between sickness absence and both pre-obesity and obesity. Women showed higher rates of sickness absence and also stronger associations were observed for female employees.[4 10 11]

Many studies that have been conducted so far employ cross-sectional designs which do not allow to draw conclusions about causal mechanisms. There is yet limited longitudinal research investigating the association between excess weight and sickness absence. While most of the *longitudinal* studies have been carried out in the US or the Scandinavian countries, evidence is still lacking for Germany. Therefore, the aim of this study was to assess the association between obesity and sickness absence using a representative sample of the German labor force in a longitudinal setting. This knowledge is important, as effective interventions to treat excess weight might also be fruitful to reduce sickness absence.

STUDY POPULATION AND METHODS

Sample

We used data from the German Socio-Economic Panel Study (SOEP), a representative longitudinal survey of the German population conducted on an annual basis since 1984.[12] The GSOEP is located at the German Institute for Economic Research (DIW Berlin). Every year, approximately 11,000 households and more than 20,000 individuals were interviewed. Topics include, for example, domain satisfaction (e.g., satisfaction with leisure time), health, or occupational status. Very high re-interview response rates were observed in the GSOEP.[13] In addition, it was found that survey attrition is low in the GSOEP.[14] Further details regarding the sampling frame as well as the survey design of the GSOEP are given elsewhere.[15]

In the current study, the analyses were based on data from six waves (2002-2012, bi-annually) because BMI was assessed only bi-annually. We restricted our sample to individuals aged 17 to 65 years, who were in the labor force and employed at all waves. All information is based on self-reports obtained by respondents.

Dependent variables

Our dependent variables were sick leave days and long-term absenteeism. Sick leave days is operationalized as the total number of working days missed due to illness in the past calendar year (*"How many days were you not able to work in 20XX because of illness? Please state all the days, not just those for which you had an official note from your doctor."*). Individuals reported the frequency of days of absence ("none", "a total of X days"). Long-term absenteeism is based on a question that assessed whether a person was sick from work for more than six weeks at one time in the previous calendar year ("*Were you sick from work for more than six weeks at one time last year?*"). Employees who reported not being sick from work for more than 6 weeks were coded as zero, while employees with a positive answer ("yes, once" and "yes, several times") were coded as ones.

Independent variables

Body mass index (BMI) was based on self-reported values of height and weight and calculated as weight divided by squared height (kg/m²). We categorized BMI into four groups according to the WHO classification as underweight (BMI ≤ 18.5 kg/m²), normal weight (18.5 kg/m² ≤ BMI < 25 kg/m²), pre-obese/overweight (25 kg/m² ≤ BMI < 30 kg/m²), and obese (BMI ≥ 30 kg/m²).[16 17]

Several sociodemographic, health-related and psychological factors that have been identified by prior research to be associated with both excess weight and productivity loss, or proposed to influence the relationship between obesity and sickness absence were entered as covariates in the analyses.[9 10 18 19] As regards sociodemographic characteristics, we considered age, gender and marital status, the latter being dichotomized with married, living together coded as one and zero otherwise (married, living separated from spouse; divorced; widowed; single). Concerning health-related and psychological factors, we included subjective health which was based on individuals' self-rated health (5-point Likert scale: 1="bad" and 5="very good") and disability assessed by a single item asking whether they were "legally classified as handicapped or capable of gainful employment only to a reduced

extent due to medical reasons" (no/yes). The disability variable served as a proxy measure for morbidity.[20 21] In addition, satisfaction with life evaluated by the question "How satisfied are you with your life, all things considered?" (11-point rating scale ranging from 0 "completely dissatisfied" to 10 "completely satisfied") was included.

Statistical analysis

We used fixed effects (FE) regression models to estimate the effect of excess weight on sickness absence. As the sick leave days is a non-negative integer number (count data), the Poisson model was chosen. To analyze the effect of excess weight on the binary outcome long-term absenteeism we employed a conditional logit fixed effects model. FE models permit correlations between unobserved time-invariant variables (e.g. genetic disposition) and predictors, yielding consistent estimates (when the strict exogeneity assumption holds).[22] The FE specification was also preferred on the basis of the Hausman test.[23]

FE models solely exploit intra-individual changes over time ("within variation"). Consequently, the effect of variables that are time-constant (e.g., gender) cannot be estimated by FE regressions.[22] Yet, FE regressions do allow for interactions between time-invariant and time-varying predictors.[24]

Therefore, we first estimated the model for the total sample (implicitly controlling for the time-invariant variable gender). In order to explore the potential gender-related differential effect of obesity, we then conducted the analysis separately for men and women. We also estimated the model including an interaction term between BMI class and gender which allows us to further test for and measure significant differences between male and female employees. This procedure was similar for both the FE Poisson model and the conditional logit FE model.

Models were tested for multicollinearity between predictor variables using the variance inflation factor. Yet, we could not detect a collinearity problem (i.e., all variance inflation factors were below 2). For the FE Poisson regressions, cluster robust standard errors were used.[25]

A P value less than 0.05 was deemed statistically significant. All analyses were performed using Stata 14.2 (Stata Corp., College Station, Texas).

RESULTS

Sample characteristics

Pooled sample characteristics for individuals included in FE regression analysis with sick leave days (column 1) and long-term absenteeism (column 2) as outcome variables are depicted in Table 1. Total observations differ among the models, as there was a varying number of changes over time in these outcome measures (intraindividual changes in sick leave days vs. intraindividual changes in long-term absenteeism). Thus, while the Poisson FE regression (with sick leave days as outcome measure) is based on 48,865 observations, the conditional FE logistic regression (with long-term absenteeism as outcome measure) is based on 9,564 observations.

In sum (Table 1, column 1), nearly one-half were female (47.8%). The mean age was 41.9 (±11.2 years; 17-64 years). Roughly two out of three (61.4%) were married, living together with spouse. Mean self-rated health equaled 2.5 (±0.8) and 93.4% were not severely disabled. The mean life satisfaction score was 7.1 (±1.6). According to the WHO categories, 1.8% were classified as underweight, 48.1% as normal weight, 35.5% as overweight, and 14.6% as obese, respectively. Please see Table 1 for further details.

Table 1. Sample characteristics for individuals included in fixed effects regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012, pooled)

	Sick leave days		Long-term absenteeism	
	N/Mean	%/SD	N/Mean	%/SD
Female	23,350	47.8%	4,658	48.7%
Age (in years)	41.9	11.2	45.4	10.4
Married, living together with spouse	30,016	61.4%	6,376	66.7%
Self-rated health (from 1= "very good" to 5 = "very bad")	2.5	0.8	2.8	0.9
Not severely disabled	45,644	93.4%	8,007	83.7%
Life satisfaction (from 0 = worst to 10 = best)	7.1	1.6	6.7	1.8
Underweight	867	1.8%	126	1.3%
Normal weight	23,524	48.1%	3,951	41.3%
Overweight	17,327	35.5%	3,632	38.0%
Obese	7,147	14.6%	1,855	19.4%
Observations	48,865		9,564	

Comments: The explanatory variable sex was not included in FE regressions as independent variable as it is time-constant (i.e., it usually did not vary within individuals over time). It was only used for descriptive purposes.

Regression analysis

Results of Poisson FE regressions with sick leave days as outcome measure are displayed in Table 2 (first column: total sample; second column: men; third column: women; fourth column: total sample with interaction terms (weight categories x gender)). Adjusting for potential confounders, regressions showed that transitions from normal weight to obesity were associated with an increase in the probability of sick leave days in women (β=.24), but not in men. The corresponding interaction term (sex x obesity) reached statistical significance (p<.01).

Furthermore, sick leave days increased with the onset of disability, increases in age as well as decreases in self-rated health and life satisfaction in the total sample and in both sexes. The outcome measure was not significantly associated with marital status.

Results of conditional FE logistic regressions (outcome measure: long-term absenteeism) are depicted in Table 3. In the first column, FE regressions for the total sample was presented. In the second and third column, FE regressions stratified by sex was presented. In the fourth column, interaction terms (weight categories x gender) were added to the regression model. Adjusting for age, marital status, self-rated health, disability, and satisfaction with life, conditional FE logistic regressions revealed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95% CI: 1.08-1.85), but not in men. Gender differences were significant (sex x overweight, p<.01).

The probability of long-term absenteeism increased with decreases in self-rated health and the onset of disability in the total sample and in both sexes. The probability of long-term absenteeism decreased with life satisfaction in the total sample and in men, but not in women. Contrarily, the probability of long-term absenteeism was positively associated with increases in age in the total sample and in women, but not in men.

Table 2. Results of Poisson FE regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of sick leave days (first column: total sample; second column: men; third column: women; fourth column: total sample with interaction term weight category x sex)

Independent variables	(1) Sick leave days – Total sample	(2) Sick leave days - Men	(3) Sick leave days - Women	(4) Sick leave days – Total sample with interaction term
Age	0.02***	0.02**	0.02***	0.02***
	(0.00)	(0.01)	(0.01)	(0.00)
Married, living together with spouse (Ref.: Others)	0.09+	0.05	0.12+	0.09+
	(0.05)	(0.08)	(0.07)	(0.05)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	0.40***	0.43***	0.37***	0.40***
	(0.02)	(0.03)	(0.03)	(0.02)
Severely disabled (Ref.: Not severely disabled)	0.82***	0.78***	0.86***	0.82***
	(0.07)	(0.09)	(0.11)	(0.07)
Life satisfaction (from 0 = worst to 10 = best)	-0.06***	-0.07***	-0.06***	-0.06***
	(0.01)	(0.02)	(0.01)	(0.01)
Underweight (Ref.: Normal weight)	-0.05	-0.31	0.00	-0.30
	(0.13)	(0.36)	(0.13)	(0.37)
Overweight (Ref.: Normal weight)	0.00	-0.09	0.09	-0.10
	(0.05)	(0.07)	(0.07)	(0.07)
Obesity (Ref.: Normal weight)	0.03	-0.16	0.24*	-0.18
	(0.08)	(0.11)	(0.11)	(0.11)
Interaction term: Underweight x sex (Ref. male)				0.30
				(0.39)
Interaction term: Overweight x sex (Ref. male)				0.20*
				(0.09)
Interaction term: Obesity x sex (Ref. male)				0.43**
				(0.16)
Observations	48,865	25,515	23,350	48,865
Number of Individuals	12,089	6,246	5,843	12,089

Poisson coefficients were reported; cluster-robust standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Table 3. Results of conditional FE regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of long-term absenteeism (first column: total sample; second column: men; third column: women; fourth column: total sample with interaction term weight category x sex)

Independent variables	(1) Long-term absenteeism – Total sample	(2) Long-term absenteeism - Men	(3) Long-term absenteeism - Women	(4) Long-term absenteeism – Total sample with interaction term
Age	1.02** (1.01 - 1.04)	1.02+ (1.00 - 1.05)	1.02* (1.00 - 1.05)	1.02** (1.01 - 1.04)
Married, living together with spouse (Ref.: Others)	1.11 (0.89 - 1.39)	1.01 (0.71 - 1.42)	1.20 (0.89 - 1.61)	1.11 (0.89 - 1.39)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.86*** (1.72 - 2.01)	1.95*** (1.75 - 2.18)	1.78*** (1.60 - 1.98)	1.86*** (1.73 - 2.01)
Severely disabled (Ref.: Not severely disabled)	2.50*** (2.02 - 3.09)	2.38*** (1.78 - 3.19)	2.62*** (1.91 - 3.59)	2.49*** (2.01 - 3.09)
Life satisfaction (from 0 = worst to 10 = best)	0.95** (0.91 - 0.98)	0.92** (0.87 - 0.98)	0.97 (0.92 - 1.03)	0.95** (0.91 - 0.99)
Underweight (Ref.: Normal weight)	0.57+ (0.30 - 1.08)	0.29 (0.06 - 1.35)	0.68 (0.34 - 1.36)	0.30 (0.07 - 1.36)
Overweight (Ref.: Normal weight)	1.08 (0.90 - 1.31)	0.84 (0.65 - 1.09)	1.41* (1.08 - 1.85)	0.83 (0.64 - 1.08)
Obesity (Ref.: Normal weight)	1.05 (0.79 - 1.41)	0.77 (0.52 - 1.15)	1.49+ (0.97 - 2.29)	0.76 (0.52 - 1.13)
Interaction term: Underweight x sex (Ref. male)				2.22 (0.42 - 11.68)
Interaction term: Overweight x sex (Ref. male)				1.70** (1.17 - 2.47)
Interaction term: Obesity x sex (Ref. male)				1.95* (1.10 - 3.46)
Pseudo R^2	.08	.09	.08	.08
Observations	9,564	4,906	4,658	9,564
Number of Individuals	2,160	1,115	1,045	2,160

Odds Ratios (OR) were reported; 95%-CI in parentheses; *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Sensitivity analysis

Since the results might be affected by attrition bias, sensitivity analyses were conducted to test the robustness of our findings. We re-estimated our models on a sample including only those individuals who were surveyed in each of the six waves. With regard to weight categories, the findings were similar to those found in our primary analyses in terms of significance and effect sizes (results not shown, but available upon request). In addition, regressions showed that transitions from normal weight to *overweight* were associated with an increase in the probability of sick leave days in women (β=.18, p<.05), but not in men (with significant interaction term, p<.05).

DISCUSSION

Based on a nationally representative sample (GSOEP), the aim of the present study was to examine the longitudinal association between obesity and sickness absence in women and in men. Data were taken from 2002 to 2012. Adjusting for potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women, but not in men (with significant gender differences). Moreover, regression analysis showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women, but not in men. Gender differences were significant.

The findings of this study generally correspond to those from prior research where overweight and obesity were suggested to be particularly related to long-term absenteeism; whereas no clear evidence for short-term absence was found.[7 8] In support of our results, existing studies found gender differences in the relationship between excess weight and absenteeism with a stronger association among women.[4 10 26]

As regards long-term absenteeism, our results are to some extent in line with the findings of a previous study conducted among Belgian workers.[10] The authors found a significant and

positive association of both overweight and obesity and high sickness absence in women but not in men. The group of obese women in our study reached only marginal significance (p<.10) though. In contrast to our results, other studies reported no significant association between BMI class and long-term sickness absence after adjusting for covariates for both men and women.[9 27]

Similar to our findings regarding sick leave days, a study among middle aged employees in the city of Helsinki, also observed a significantly increased risk of sickness absence for obese but not for overweight women, yet only for very short (less than 4 days) spells or spells longer than 14 days.[26] These findings disagree with the results from a London-based cohort study that reported significant associations between obesity and sick leave for both short and longer spells for both sexes.[11]

While in general higher rates of female sick leave have been reported, the significant interaction effect of gender and BMI on both sick leave days and long-term absenteeism may be further explained by unobserved psychological or psychosocial factors. Overweight and obesity have been proposed to exert a negative effect on one's body image and self-esteem and this tends to be more pronounced in women, as they may be more affected by the slim ideal compared to men.[28 29] In addition, perceived weight might play a role in the relationship between weight and sickness absence, insofar as negative weight perceptions may lead to higher levels of dissatisfaction and psychological distress, specifically in women.[30] Furthermore, overweight and obese women are more often targets of weight stigmatization, weight discrimination and prejudice (e.g., laziness, less self-control, work refusal), in particular regarding the workplace setting.[31-33] This may lead to higher risk of feelings of stress thereby reducing job resources and increasing job strain. Consequently, they may be more likely to employ poor coping strategies (e.g., escaping or avoiding distressing situations) which could eventually result in withdrawal behaviors such as sick leave.[27 30]

Our results suggest a significant association between both the health–related and psychological covariates and illness-related sickness absence. This is in line with findings from previous studies reporting significant effects of self-rated health[10 18] and morbidity[11 34] on sickness absence. Similarly, a relationship between satisfaction with life and sick leave was referred by previous research.[35 36] Concerning marital status heterogeneous findings have been reported depending on its categorization; but generally marital status was related to sick leave with a trend towards lower sickness absence among married individuals.[37] This finding could not be confirmed in our study.

However, it should be stressed that direct comparisons of our results and those of previous studies are difficult because of difference in the measurement of (short- and long-term) sickness absence, differences in the study design (cross-sectional versus longitudinal), heterogeneity of the study population and the setting.

In total, results of this longitudinal study add to evidence from previous correlational studies, which suggest that obesity is associated with long-term absenteeism cross-sectionally. Data came from a large nationally representative sample of German individuals (GSOEP). Individuals were observed over a long period (2002 to 2012). By using FE regressions, the problem of unobserved heterogeneity was diminished.[24]

Because sick pay is shortened after six weeks and not paid any longer by the employer but by a third-party payer (e.g., health insurance), and a different medical certificate has to be provided, it is expected that employees will quite accurately remember their sick leave spells. Hence, this indicator should be less prone to measurement error.[38]

The self-rated BMI was used to classify obesity. As individuals tend to overestimate height and underestimate weight,[39] the BMI might be biased downwards. However, under the assumption that this bias is constant within individuals over time, this does not bias the FE estimates. In addition, a prior study investigating the predictive performance of different body weight measures on sickness absence found that self-reported BMI performed equally well

as measured BMI.[40] Moreover, it is worth emphasizing that panel attrition might bias the FE estimates. However, it has been shown that panel attrition is quite low in the GSOEP.[14] In addition, the sensitivity analysis conducted indicates that attrition bias might be rather small. In addition, long-term absenteeism and sick leave days were quantified retrospectively. Hence, we cannot rule out that the outcome measures affects weight change (endogeneity bias).

To conclude, our findings highlight the longitudinal association between excess weight and workplace absenteeism. Effective interventions to treat excess weight might also be a promising strategy to reduce sickness absence in women.

CONTRIBUTORS

KCR, HHK and AH made substantial contributions to conception and design of the study, the analysis and interpretation of data and drafted the manuscript. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

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ETHICS APPROVAL

An ethical approval was not obtained because criteria for the need of an ethical statement were not met (risk for the respondents, lack of information about the aims of the study, examination of patients). However, the German Council of Science and Humanities (Wissenschaftsrat) evaluated the German Socio-Economic Panel (GSOEP) at the Deutsches Institut für Wirtschaftsforschung, (DIW), Berlin. The German Council of Science and Humanities approved the GSOEP. The GSOEP is in accordance with the Helsinki Declaration as revised in 2008.

Informed consent was obtained from all participants.

DATA SHARING STATEMENT

GSOEP data access must comply with high security standards for maintaining confidentiality and protecting personal privacy. The data are also subject to regulations limiting their use to scientific purposes, that is, they are only made available to the scientific community (in German language only). After conclusion of a data distribution contract with DIW Berlin, the data of every new wave will be available on request either via personalized encrypted download or via certified mail on a DVD. Please see for further information: https://www.diw.de/en/diw_02.c.238237.en/conditions.html.

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Obesity and sickness absence – Results from a longitudinal nationally representative sample from Germany

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Obesity and sickness absence – Results from a longitudinal nationally representative sample from Germany

Running head: Obesity and sick leave days

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ABSTRACT

Objectives: The current study aimed at investigating the longitudinal association between obesity and sickness absence in women and men in Germany.

Methods: Data were derived from the German Socio-Economic Panel (GSOEP), which is a nationally representative, longitudinal study of private households in Germany. We draw on data from 2002 through 2012. Information on self-rated BMI has been collected every second wave since 2002. Sick leave days (total number of working days missed due to illness in the past calendar year) and sick from work for more than six weeks in the preceding 12 months (yes; no) were used as outcome measures. Fixed effects (FE) regression models were used for the total sample and stratified by sex. Gender differences were examined using interaction terms (sex x weight category).

Results: Controlling for several potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women (β=.24, p<.05) but not in men – with significant gender differences (sex x obesity, p<.01). Moreover, conditional FE logistic regressions showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95%-CI: 1.08-1.85) but not in men. Gender differences were significant (sex x overweight, p<.01).

Conclusions: Our findings stress the longitudinal association between excess weight and increased likelihood of sick leave days as well as long-term absenteeism in women.

Keywords: long-term absenteeism; sick leave days; body-mass-index; excess weight; longitudinal studies

Strengths and limitations of this study

- Data came from a large nationally representative sample of German individuals.
- Panel regression models were used, diminishing the problem of unobserved heterogeneity.
- The self-rated BMI was used to classify obesity.

INTRODUCTION

Obesity remains a major health concern in Western societies [1]. Behind the Americas, Europe ranks second regarding the proportion of overweight (25 kg/m² ≤ BMI < 30 kg/m²) or obese (BMI ≥ 30 kg/m²) people, according to the WHO statistics. The share of men and women being 18 years and over having a body mass index (BMI) ≥ 25 kg/m² amounts to 59.1% and 44.7%, respectively, and in the EU-28. For Germany, the prevalence of adult obesity has recently been estimated to range between 16.5%-23.9% in women and 17.3%-23.3% in men.[2 3] Obesity and its related adverse health effects pose a considerable burden to the healthcare system because of both its direct costs incurred by increased health service utilization and indirect costs arising from reduced or lost workforce productivity.[4 5] Several studies found that indirect costs of overweight and obesity make up the majority (51%-59%) of total costs, thus exceeding direct costs.[6] Unsurprisingly, the impact of obesity on the workplace in terms of absence from work due to excess weight related illnesses or other factors continues to be of primary interest to health policy makers and employers.

The association between obesity and sickness absence has been well documented cross-sectionally. Studies found a tendency for obese individuals to have a higher number of sick leave events and also have longer spells of individual sick leave compared to their normal-weight counterparts.[4 7 8] As regards pre-obesity / overweight, inconsistent results have been reported in literature for the association with sickness absence. While some studies found evidence of an elevated risk of sick leave for pre-obese subjects, others reported no significant association when compared to normal-weight subjects.[7 8] However, in general, there tended to be a positive relationship between higher levels of BMI and sick leave, although available results pertaining to short-term spells were less clear, which may be due to discrepant definitions of short-term sick leave.[7-9] Findings further suggested gender differences regarding the association between sickness absence and both pre-obesity and obesity. Women showed higher rates of sickness absence and also stronger associations were observed for female employees.[4 10 11]

Many studies that have been conducted so far employ cross-sectional designs which do not allow drawing conclusions about causal mechanisms. So far there is yet limited longitudinal research investigating the association between excess weight and sickness absence. While most of the *longitudinal* studies have been carried out in the US or the Scandinavian countries, evidence is still lacking for Germany. Therefore, the aim of this study was to assess the association between obesity and sickness absence using a representative sample of the German labor force in a longitudinal setting.

STUDY POPULATION AND METHODS

Sample

We used data from the German Socio-Economic Panel Study (GSOEP), a representative longitudinal survey of the German population conducted on an annual basis since 1984.[12] The GSOEP is located at the German Institute for Economic Research (DIW Berlin). It is a household panel like the Panel Study of Income Dynamics in the US (PSID) or the British Household Panel Study (BHPS). Every year, approximately 11,000 households and more than 20,000 individuals were interviewed. All adult household members (aged 17 and over) are interviewed. Topics include, for example, domain satisfaction (e.g., satisfaction with leisure time), health, or occupational status. Very high re-interview response rates were observed in the GSOEP.[13] In addition, it was found that survey attrition is low in the GSOEP.[14] Further details regarding the sampling frame as well as the survey design of the GSOEP are given elsewhere.[15]

In the current study, the analyses were based on data from six waves (2002-2012, bi-annually), because BMI was assessed only bi-annually. We restricted our sample to individuals aged 17 to 65 years who were in the labor force and employed at all waves. Thus, while regression analysis with sick leave days as outcome measure is based on 48,865

observations, the regression analysis with long-term absenteeism as outcome measure is based on 9,564 observations.

All information is based on self-reports obtained by respondents.

Dependent variables

Our dependent variables were sick leave days and long-term absenteeism. Sick leave days is operationalized as the total number of working days missed due to illness in the past calendar year (*"How many days were you not able to work in 20XX because of illness? Please state all the days, not just those for which you had an official note from your doctor."*). Individuals reported the frequency of days of absence ("none", "a total of X days"). Long-term absenteeism is based on a question that assessed whether a person was sick from work for more than six weeks at one time in the previous calendar year ("*Were you sick from work for more than six weeks at one time last year?*"). Employees who reported not being sick from work for more than 6 weeks were coded as zero, while employees with a positive answer ("yes, once" and "yes, several times") were coded as ones.

Independent variables

Body mass index (BMI) was based on self-reported values of height and weight and calculated as weight divided by squared height (kg/m²). We categorized BMI into four groups according to the WHO classification as underweight (BMI ≤ 18.5 kg/m²), normal weight (18.5 kg/m² ≤ BMI < 25 kg/m²), pre-obese/overweight (25 kg/m² ≤ BMI < 30 kg/m²), and obese (BMI ≥ 30 kg/m²).[16 17]

Several sociodemographic, health-related and subjective well-being factors that have been identified by prior research to be associated with both excess weight and productivity loss, or proposed to influence the relationship between obesity and sickness absence were entered as covariates in the analyses.[9 10 18 19] As regards sociodemographic characteristics, we considered age, sex and marital status, the latter being dichotomized with married, living together coded as one and zero otherwise (i.e., married, but living separated from spouse;

divorced; widowed; single are coded as zero). Concerning health-related and subjective well-being factors, we included *subjective* health, which was based on individuals' self-rated health (5-point Likert scale: 1="bad" and 5="very good") and disability assessed by a single item asking whether they were "legally classified as handicapped or capable of gainful employment only to a reduced extent due to medical reasons" (no/yes). The disability variable served as a proxy measure for *objective* morbidity.[20 21] In accordance with prior research [22], the continuous variable satisfaction with life evaluated by the question "How satisfied are you with your life, all things considered?" (11-point rating scale ranging from 0 "completely dissatisfied" to 10 "completely satisfied") was included.

Statistical analysis

We used fixed effects (FE) regression models to estimate the longitudinal association between excess weight and sickness absence. As the sick leave days is a non-negative integer number (count data), the Poisson model was chosen. To analyze the longitudinal association between excess weight and the binary outcome long-term absenteeism, we employed a conditional logit fixed effects model. FE models permit correlations between unobserved time-invariant variables (e.g. genetic disposition) and predictors, yielding consistent estimates (when the strict exogeneity assumption holds).[23]

Our main goal was to provide consistent estimates under very weak assumptions. [23 24] Therefore, FE regressions were used. The FE specification was also preferred based on the Hausman test.[25] For example, the Hausman test statistic was $X^2=838.31$, $p<.001$ (with sick leave days as outcome measure).

FE models solely exploit intra-individual changes over time ("within variation"). Consequently, the effect of variables that are time-constant (e.g., sex) cannot be estimated by FE regressions.[23] Yet, FE regressions do allow for interactions between time-invariant and time-varying predictors.[24]

Therefore, we first estimated the model for the total sample (implicitly controlling for the time-invariant variable sex). In order to explore the potential gender-related differential association with obesity, we then conducted the analysis separately for men and women. We also estimated the model, including an interaction term between BMI class and sex, which allows us to further test for and measure significant differences between male and female employees. This procedure was similar for both the FE Poisson model and the conditional logit FE model.

Models were tested for multicollinearity between predictor variables using the variance inflation factor. Yet we could not detect a collinearity problem (i.e., all variance inflation factors were below 2). For the FE Poisson regressions, cluster robust standard errors were used.[26]

A P value less than 0.05 was deemed statistically significant. All analyses were performed using Stata 14.2 (Stata Corp., College Station, Texas).

RESULTS

Sample characteristics

Pooled sample characteristics for individuals included in FE regression analysis with sick leave days (column 1) and long-term absenteeism (column 2) as outcome variables are described in Table 1. Total observations differ among the models, as there was a varying number of changes over time in these outcome measures (intraindividual changes in sick leave days vs. intraindividual changes in long-term absenteeism). Thus, while the Poisson FE regression (with sick leave days as outcome measure) is based on 48,865 observations, the conditional FE logistic regression (with long-term absenteeism as outcome measure) is based on 9,564 observations. It might be the case that individuals with within-variation on sick leave days also provide within-information on long-term absenteeism. However, it is not necessarily the case.

In total (Table 1, columns 1 and 2), nearly one-half were female (47.8% in the sample with sick leave days as outcome, 48.7% in the sample with long-term absenteeism as outcome). The mean age was 41.9 (±11.2 years; 17-64 years) and 45.4 (±10.4 years; 17-64 years) in the sick leave days sample and in the long-term absenteeism sample, respectively. According to the WHO categories, 1.8% were classified as underweight, 48.1% as normal weight, 35.5% as overweight, and 14.6% as obese, respectively in the sick leave days sample. In the sample with long-term absenteeism as outcome, 1.3% were classified as underweight, 41.3% as normal weight, 38.0% as overweight, and 19.4% as obese, respectively. Please see Table 1 for further details.

Table 1. Sample characteristics for individuals included in fixed effects regressions for the outcomes sick leave days and long-term absenteeism (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012, pooled)

	Sick leave days (n=48,865)		Long-term absenteeism (n=9,564)	
	N/Mean	%/SD	N/Mean	%/SD
Female	23,350	47.8%	4,658	48.7%
Age (in years)	41.9	11.2	45.4	10.4
Married, living together with spouse	30,016	61.4%	6,376	66.7%
Self-rated health (from 1= "very good" to 5 = "very bad")	2.5	0.8	2.8	0.9
Not severely disabled	45,644	93.4%	8,007	83.7%
Life satisfaction (from 0 = worst to 10 = best)	7.1	1.6	6.7	1.8
Underweight	867	1.8%	126	1.3%
Normal weight	23,524	48.1%	3,951	41.3%
Overweight	17,327	35.5%	3,632	38.0%
Obese	7,147	14.6%	1,855	19.4%

Comments: The explanatory variable sex was not included in FE regressions as independent variable, as it is time-constant (i.e., it usually did not vary within individuals over time). It was only used for descriptive purposes.

Regression analysis

Results of Poisson FE regressions with sick leave days as outcome measure are displayed in Table 2. Adjusting for potential confounders, regressions showed that transitions from normal weight to obesity were associated with an increase in the probability of sick leave days in women (β=.24), but not in men. The corresponding interaction term (sex x obesity) reached statistical significance (p<.01).

Furthermore, sick leave days increased with the onset of disability, increases in age as well as decreases in self-rated health and life satisfaction in the total sample and in both sexes. The outcome measure was not significantly associated with marital status.

Results of conditional FE logistic regressions (outcome measure: long-term absenteeism) are described in Table 3. Adjusting for age, marital status, self-rated health, disability, and satisfaction with life, conditional FE logistic regressions revealed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95% CI: 1.08-1.85), but not in men. Gender differences were significant (sex x overweight, p<.01).

The probability of long-term absenteeism increased with decreases in self-rated health and the onset of disability in the total sample and in both sexes. The probability of long-term absenteeism decreased with life satisfaction in the total sample and in men, but not in women. Contrarily, the probability of long-term absenteeism was positively associated with increases in age in the total sample and in women, but not in men.

Table 2. Results of Poisson FE regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of sick leave days (Poisson coefficients were reported; 95%-CI in parentheses)

Independent variables	(1) Sick leave days – Total sample	(2) Sick leave days - Men	(3) Sick leave days - Women	(4) Sick leave days – Total sample with interaction term
Age	0.02*** (0.01 - 0.03)	0.02** (0.00 - 0.03)	0.02*** (0.01 - 0.03)	0.02*** (0.01 - 0.03)
Married, living together with spouse (Ref.: Others)	0.09+ (-0.02 - 0.19)	0.05 (-0.11 - 0.20)	0.12+ (-0.02 - 0.27)	0.09+ (-0.02 - 0.19)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	0.40*** (0.36 - 0.44)	0.43*** (0.38 - 0.49)	0.37*** (0.32 - 0.43)	0.40*** (0.36 - 0.44)
Severely disabled (Ref.: Not severely disabled)	0.82*** (0.69 - 0.96)	0.78*** (0.60 - 0.97)	0.86*** (0.66 - 1.07)	0.82*** (0.68 - 0.96)
Life satisfaction (from 0 = worst to 10 = best)	-0.06*** (-0.08 - -0.04)	-0.07*** (-0.10 - -0.04)	-0.06*** (-0.08 - -0.03)	-0.06*** (-0.08 - -0.04)
Underweight (Ref.: Normal weight)	-0.05 (-0.31 - 0.20)	-0.31 (-1.01 - 0.40)	0.00 (-0.26 - 0.27)	-0.30 (-1.02 - 0.42)
Overweight (Ref.: Normal weight)	0.00 (-0.09 - 0.09)	-0.09 (-0.22 - 0.04)	0.09 (-0.04 - 0.22)	-0.10 (-0.22 - 0.03)
Obesity (Ref.: Normal weight)	0.03 (-0.13 - 0.18)	-0.16 (-0.38 - 0.06)	0.24* (0.02 - 0.45)	-0.18 (-0.40 - 0.04)
Interaction term: Underweight x sex (Ref. male)				0.30 (-0.47 - 1.06)
Interaction term: Overweight x sex (Ref. male)				0.20* (0.02 - 0.38)
Interaction term: Obesity x sex (Ref. male)				0.43** (0.12 - 0.73)
Observations	48,865	25,515	23,350	48,865
Number of Individuals	12,089	6,246	5,843	12,089

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Table 3. Results of conditional FE regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of long-term absenteeism (Odds Ratios (OR) were reported; 95%-CI in parentheses)

Independent variables	(1) Long-term absenteeism – Total sample	(2) Long-term absenteeism - Men	(3) Long-term absenteeism - Women	(4) Long-term absenteeism – Total sample with interaction term
Age	1.02** (1.01 - 1.04)	1.02+ (1.00 - 1.05)	1.02* (1.00 - 1.05)	1.02** (1.01 - 1.04)
Married, living together with spouse (Ref.: Others)	1.11 (0.89 - 1.39)	1.01 (0.71 - 1.42)	1.20 (0.89 - 1.61)	1.11 (0.89 - 1.39)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.86*** (1.72 - 2.01)	1.95*** (1.75 - 2.18)	1.78*** (1.60 - 1.98)	1.86*** (1.73 - 2.01)
Severely disabled (Ref.: Not severely disabled)	2.50*** (2.02 - 3.09)	2.38*** (1.78 - 3.19)	2.62*** (1.91 - 3.59)	2.49*** (2.01 - 3.09)
Life satisfaction (from 0 = worst to 10 = best)	0.95** (0.91 - 0.98)	0.92** (0.87 - 0.98)	0.97 (0.92 - 1.03)	0.95** (0.91 - 0.99)
Underweight (Ref.: Normal weight)	0.57+ (0.30 - 1.08)	0.29 (0.06 - 1.35)	0.68 (0.34 - 1.36)	0.30 (0.07 - 1.36)
Overweight (Ref.: Normal weight)	1.08 (0.90 - 1.31)	0.84 (0.65 - 1.09)	1.41* (1.08 - 1.85)	0.83 (0.64 - 1.08)
Obesity (Ref.: Normal weight)	1.05 (0.79 - 1.41)	0.77 (0.52 - 1.15)	1.49+ (0.97 - 2.29)	0.76 (0.52 - 1.13)
Interaction term: Underweight x sex (Ref. male)				2.22 (0.42 - 11.68)
Interaction term: Overweight x sex (Ref. male)				1.70** (1.17 - 2.47)
Interaction term: Obesity x sex (Ref. male)				1.95* (1.10 - 3.46)
Pseudo R^2	.08	.09	.08	.08
Observations	9,564	4,906	4,658	9,564
Number of Individuals	2,160	1,115	1,045	2,160

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Sensitivity analysis

Since the results might be affected by attrition bias, sensitivity analyses were conducted to test the robustness of our findings. We re-estimated our models on a sample including only those individuals who were surveyed in each of the six waves (27,592 observations with sick leave days as outcome measure; 6,139 observations with long-term absenteeism as outcome measure).

With regard to weight categories, the findings were similar to those found in our primary analyses in terms of significance and effect sizes (results not shown, but available upon request). In addition, regressions showed that transitions from normal weight to *overweight* were associated with an increase in the probability of sick leave days in women (β=.18, $p<.05$), but not in men (with significant interaction term, $p<.05$).

DISCUSSION

Based on a nationally representative sample (GSOEP), the aim of the present study was to examine the longitudinal association between obesity and sickness absence in women and in men. Knowledge regarding the longitudinal association between obesity and sickness absence (and the moderating role of sex) is important for implementing strategies to tackle this problem. Data were taken from 2002 to 2012. Adjusting for potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women, but not in men (with significant gender differences). Moreover, regression analysis showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women, but not in men.

The findings of this study generally correspond to those from prior research where overweight and obesity were suggested to be particularly related to long-term absenteeism; whereas no clear evidence for short-term absence was found.[7 8] In support of our results,

existing studies found gender differences in the relationship between excess weight and absenteeism with a stronger association among women.[4 10 27]

As regards long-term absenteeism, our results are to some extent in line with the findings of a previous study conducted among Belgian workers.[10] The authors found a significant and positive association of both overweight and obesity and high sickness absence in women but not in men. The group of obese women in our study reached only marginal significance ($p<.10$) though. In contrast to our results, other studies reported no significant association between BMI class and long-term sickness absence after adjusting for covariates for both men and women.[9 28]

Similar to our findings regarding sick leave days, a study among middle aged employees in the city of Helsinki also observed a significantly increased risk of sickness absence for obese but not for overweight women, yet only for very short (less than 4 days) spells or spells longer than 14 days.[27] These findings disagree with the results from a London-based cohort study that reported significant associations between obesity and sick leave for both short and longer spells for both sexes.[11]

While higher rates of female sick leave have been reported in general, the significant interaction effect of sex and BMI on both sick leave days and long-term absenteeism may be further explained by unobserved psychological or psychosocial factors. Overweight and obesity have been proposed to exert a negative effect on one's body image and self-esteem, and this tends to be more pronounced in women, as they may be more affected by the slim ideal compared to men.[29 30] In addition, perceived weight might play a role in the relationship between weight and sickness absence, insofar as negative weight perceptions may lead to higher levels of dissatisfaction and psychological distress, specifically in women.[31] Furthermore, overweight and obese women are more often targets of weight stigmatization, weight discrimination and prejudice (e.g., laziness, less self-control, work refusal), in particular regarding the workplace setting.[32-34] This may lead to higher risk of feelings of

stress, thereby reducing job resources and increasing job strain. Consequently, they may be more likely to employ poor coping strategies (e.g., escaping or avoiding distressing situations) which could eventually result in withdrawal behaviors such as sick leave.[28 31]

Another explanation might be that medical consequences (e.g., musculoskeletal diseases, cardiovascular diseases or diabetes) of obesity differ to some extent between women and men [35 36]. Ultimately, these differences in morbidity might lead to differences in sickness absence between women and men. However, future research is needed to investigate this relationship.

Our results suggest a significant association between both the health–related and life satisfaction covariates and illness-related sickness absence. This is in line with findings from previous studies reporting significant effects of self-rated health[10 18] and morbidity[11 37] on sickness absence. Similarly, a relationship between satisfaction with life and sick leave was referred to by previous research.[38 39] Concerning marital status, heterogeneous findings have been reported depending on its categorization, but generally marital status was related to sick leave with a trend towards lower sickness absence among married individuals.[40] This finding could not be confirmed in our study.

However, it should be stressed that direct comparisons of our results and those of previous studies are difficult because of differences in the measurement of (short- and long-term) sickness absence, differences in the study design (cross-sectional versus longitudinal), heterogeneity of the study population and the setting.

In total, results of this longitudinal study add to evidence from previous correlational studies, which suggest that obesity is associated with long-term absenteeism cross-sectionally [7 8]. Data came from a large nationally representative sample of German individuals (GSOEP). Individuals were observed over a long period (2002 to 2012). By using FE regressions, the problem of unobserved heterogeneity was diminished.[24]

Because in Germany sick pay is shortened after six weeks and not paid any longer by the employer but by a third-party payer (e.g. health insurance), and a different medical certificate has to be provided, it is expected that employees will quite accurately remember their sick leave spells. Hence, this indicator should be less prone to measurement error.[41] As regards sick leave days, we cannot dismiss the possibility of a recall bias. However, it has been shown that self-reported sick leave can be employed as a proxy measure when administrative data are not available.[42]

The self-rated BMI was used to classify obesity. As individuals tend to overestimate height and underestimate weight,[43] the BMI might be biased downwards. However, under the assumption that this bias is constant within individuals over time, this does not bias the FE estimates. In addition, a prior study investigating the predictive performance of different body weight measures on sickness absence found that self-reported BMI performed equally well as measured BMI.[44] Moreover, it is worth emphasizing that panel attrition might bias the FE estimates. However, it has been shown that panel attrition is quite low in the GSOEP.[14] In addition, the sensitivity analysis conducted indicates that attrition bias might be rather small. In addition, long-term absenteeism and sick leave days were quantified retrospectively. Hence, we cannot rule out that the outcome measures affect BMI change (endogeneity bias). Thus, future studies (e.g. based on panel instrumental variable procedures) are needed to overcome these problems.

To conclude, our findings highlight the longitudinal association between excess weight and workplace absenteeism. Effective interventions to treat excess weight might also be a promising strategy to reduce sickness absence in women.

CONTRIBUTORS

KCR, HHK and AH made substantial contributions to conception and design of the study, the analysis and interpretation of data and drafted the manuscript. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

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ETHICS APPROVAL

The German Council of Science and Humanities (Wissenschaftsrat) evaluated the German Socio-Economic Panel (GSOEP) at the Deutsches Institut für Wirtschaftsforschung, (DIW), Berlin. The German Council of Science and Humanities approved the GSOEP. The GSOEP is in accordance with the Helsinki Declaration as revised in 2008.

Informed consent was obtained from all participants.

DATA SHARING STATEMENT

GSOEP data access must comply with high security standards for maintaining confidentiality and protecting personal privacy. The data are also subject to regulations limiting their use to scientific purposes; that is, they are only made available to the scientific community (in German language only). After conclusion of a data distribution contract with DIW Berlin, the data of every new wave will be available on request either via personalized encrypted download or via certified mail on a DVD. Please see for further information: https://www.diw.de/en/diw_02.c.238237.en/conditions.html.

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Obesity and sickness absence – Results from a longitudinal nationally representative sample from Germany

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Obesity and sickness absence – Results from a longitudinal nationally representative sample from Germany

Running head: Obesity and sick leave days

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ABSTRACT

Objectives: The current study aimed at investigating the longitudinal association between obesity and sickness absence in women and men in Germany.

Methods: Data were derived from the German Socio-Economic Panel (GSOEP), which is a nationally representative, longitudinal study of private households in Germany. We draw on data from 2002 through 2012. Information on self-rated BMI has been collected every second wave since 2002. Sick leave days (total number of working days missed due to illness in the past calendar year) and sick from work for more than six weeks in the preceding 12 months (yes; no) were used as outcome measures. Fixed effects (FE) regression models were used for the total sample and stratified by sex. Gender differences were examined using interaction terms (sex x weight category).

Results: Controlling for several potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women (incidence rate ratio (IRR): 1.27, 95% CI: 1.02-1.57) but not in men (IRR: 0.85, 95 % CI: 0.68-1.06) – with significant gender differences (sex x obesity, p<.01). Moreover, conditional FE logistic regressions showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95% CI: 1.08-1.85) but not in men (overweight, OR: 0.84, 95% CI: 0.65-1.09). Gender differences were significant (sex x overweight, p<.01).

Conclusions: Our findings stress the longitudinal association between excess weight and increased likelihood of sick leave days as well as long-term absenteeism in women.

Keywords: long-term absenteeism; sick leave days; body-mass-index; excess weight; longitudinal studies

Strengths and limitations of this study

- Data came from a large nationally representative sample of German individuals.
- Panel regression models were used, diminishing the problem of unobserved heterogeneity.
- The possibility of reverse causality cannot be dismissed.
- The self-rated BMI was used to classify obesity.

INTRODUCTION

Obesity remains a major health concern in Western societies [1]. Behind the Americas, Europe ranks second regarding the proportion of overweight (25 kg/m² ≤ BMI < 30 kg/m²) or obese (BMI ≥ 30 kg/m²) people, according to the WHO statistics. The share of men and women being 18 years and over having a body mass index (BMI) ≥ 25 kg/m² amounts to 59.1% and 44.7%, respectively, and in the EU-28. For Germany, the prevalence of adult obesity has recently been estimated to range between 16.5%-23.9% in women and 17.3%-23.3% in men.[2 3] Obesity and its related adverse health effects pose a considerable burden to the healthcare system because of both its direct costs incurred by increased health service utilization and indirect costs arising from reduced or lost workforce productivity.[4 5] Several studies found that indirect costs of overweight and obesity make up the majority (51%-59%) of total costs, thus exceeding direct costs.[6] Unsurprisingly, the impact of obesity on the workplace in terms of absence from work due to excess weight related illnesses or other factors continues to be of primary interest to health policy makers and employers.

The association between obesity and sickness absence has been well documented cross-sectionally. Studies found a tendency for obese individuals to have a higher number of sick leave events and also have longer spells of individual sick leave compared to their normal-weight counterparts.[4 7 8] As regards pre-obesity / overweight, inconsistent results have been reported in literature for the association with sickness absence. While some studies found evidence of an elevated risk of sick leave for pre-obese subjects, others reported no significant association when compared to normal-weight subjects.[7 8] However, in general, there tended to be a positive relationship between higher levels of BMI and sick leave, although available results pertaining to short-term spells were less clear, which may be due to discrepant definitions of short-term sick leave.[7-9] Findings further suggested gender differences regarding the association between sickness absence and both pre-obesity and obesity. Women showed higher rates of sickness absence and also stronger associations were observed for female employees.[4 10 11]

Many studies that have been conducted so far employ cross-sectional designs which do not allow drawing conclusions about causal mechanisms. So far there is yet limited longitudinal research investigating the association between excess weight and sickness absence. While most of the *longitudinal* studies have been carried out in the US or the Scandinavian countries, evidence is still lacking for Germany. Therefore, the aim of this study was to assess the association between obesity and sickness absence using a representative sample of the German labor force in a longitudinal setting.

STUDY POPULATION AND METHODS

Sample

We used data from the German Socio-Economic Panel Study (GSOEP), a representative longitudinal survey of the German population conducted on an annual basis since 1984.[12] The GSOEP is located at the German Institute for Economic Research (DIW Berlin). It is a household panel like the Panel Study of Income Dynamics in the US (PSID) or the British Household Panel Study (BHPS). Every year, approximately 11,000 households and more than 20,000 individuals were interviewed. All adult household members (aged 17 and over) are interviewed. Topics include, for example, domain satisfaction (e.g., satisfaction with leisure time), health, or occupational status. Very high re-interview response rates were observed in the GSOEP.[13] In addition, it was found that survey attrition is low in the GSOEP (in most years and sub-samples, attrition was less than 10%[14]).[15] Further details regarding the sampling frame as well as the survey design of the GSOEP are given elsewhere.[16]

In the current study, the analyses were based on data from six waves (2002-2012, bi-annually), because BMI was assessed only bi-annually. We restricted our sample to individuals aged 17 to 65 years who were in the labor force and employed at all waves. Thus, while regression analysis with sick leave days as outcome measure is based on 48,865

observations, the regression analysis with long-term absenteeism as outcome measure is based on 9,564 observations.

All information is based on self-reports obtained by respondents.

Dependent variables

Our dependent variables were sick leave days and long-term absenteeism. Sick leave days is operationalized as the total number of working days missed due to illness in the past calendar year (*"How many days were you not able to work in 20XX because of illness? Please state all the days, not just those for which you had an official note from your doctor."*). Individuals reported the frequency of days of absence ("none", "a total of X days"). Long-term absenteeism is based on a question that assessed whether a person was sick from work for more than six weeks at one time in the previous calendar year ("*Were you sick from work for more than six weeks at one time last year?*"). Employees who reported not being sick from work for more than 6 weeks were coded as zero, while employees with a positive answer ("yes, once" and "yes, several times") were coded as ones.

Independent variables

Body mass index (BMI) was based on self-reported values of height and weight and calculated as weight divided by squared height (kg/m²). We categorized BMI into four groups according to the WHO classification as underweight (BMI ≤ 18.5 kg/m²), normal weight (18.5 kg/m² ≤ BMI < 25 kg/m²), pre-obese/overweight (25 kg/m² ≤ BMI < 30 kg/m²), and obese (BMI ≥ 30 kg/m²).[17 18]

Several sociodemographic, health-related and subjective well-being factors that have been identified by prior research to be associated with both excess weight and productivity loss, or proposed to influence the relationship between obesity and sickness absence were entered as potential confounders in the analyses.[9 10 19 20] As regards sociodemographic characteristics, we considered age, and marital status, the latter being dichotomized with married, living together coded as one and zero otherwise (i.e., married, but living separated

from spouse; divorced; widowed; single are coded as zero). Concerning health-related and subjective well-being factors, we included *subjective* health, which was based on individuals' self-rated health (5-point Likert scale: 1="bad" and 5="very good") and disability assessed by a single item asking whether they were "legally classified as handicapped or capable of gainful employment only to a reduced extent due to medical reasons" (no/yes). The disability variable served as a proxy measure for *objective* morbidity.[21 22] In accordance with prior research [23], the continuous variable satisfaction with life evaluated by the question "How satisfied are you with your life, all things considered?" (11-point rating scale ranging from 0 "completely dissatisfied" to 10 "completely satisfied") was included. Moreover, the time-invariant variable sex was used for descriptive purposes.

Statistical analysis

We used fixed effects (FE) regression models to estimate the longitudinal association between excess weight and sickness absence. As the sick leave days is a non-negative integer number (count data), the Poisson model was chosen. To analyze the longitudinal association between excess weight and the binary outcome long-term absenteeism, we employed a conditional logit fixed effects model, which is a common method for panel data analysis. FE models permit correlations between unobserved time-invariant variables (e.g. genetic disposition) and predictors, yielding consistent estimates (when the strict exogeneity assumption holds).[24]

Our main goal was to provide consistent estimates under very weak assumptions. [24 25] Therefore, FE regressions were used. The FE specification was also preferred based on the Hausman test.[26] For example, the Hausman test statistic was $X^2=838.31$, $p<.001$ (with sick leave days as outcome measure).

FE models solely exploit changes within units (here: participants) over time ("within variation"). Consequently, the effect of variables that are time-constant (e.g., sex) cannot be

estimated by FE regressions.[24] Yet, FE regressions do allow for interactions between time-invariant and time-varying predictors.[25]

Therefore, we first estimated the model for the total sample (implicitly controlling for the time-invariant variable sex). In order to explore the potential gender-related differential association with obesity, we then conducted the analysis separately for men and women. We also estimated the model, including an interaction term between BMI class and sex, which allows us to further test for and measure significant differences between male and female employees. This procedure was similar for both the FE Poisson model and the conditional logit FE model.

Models were tested for multicollinearity between predictor variables using the variance inflation factor. Yet we could not detect a collinearity problem (i.e., all variance inflation factors were below 2). For the FE Poisson regressions, cluster robust standard errors were used.[27]

A P value less than 0.05 was deemed statistically significant. All analyses were performed using Stata 14.2 (Stata Corp., College Station, Texas).

Patient and Public Involvement

No patients were directly involved in the development of the research question, selection of the outcome measures, design and implementation of the study, or interpretation of the results.

RESULTS

Sample characteristics

Pooled sample characteristics for individuals included in FE regression analysis with sick leave days (column 1) and long-term absenteeism (column 2) as outcome variables are described in Table 1. Total observations differ among the models, as there was a varying

number of changes over time in these outcome measures (intraindividual changes in sick leave days vs. intraindividual changes in long-term absenteeism). Thus, while the Poisson FE regression (with sick leave days as outcome measure) is based on 48,865 observations, the conditional FE logistic regression (with long-term absenteeism as outcome measure) is based on 9,564 observations. It might be the case that individuals with within-variation on sick leave days also provide within-information on long-term absenteeism. However, it is not necessarily the case.

In total (Table 1, columns 1 and 2), nearly one-half were female (47.8% in the sample with sick leave days as outcome, 48.7% in the sample with long-term absenteeism as outcome). The mean age was 41.9 (±11.2 years; 17-64 years) and 45.4 (±10.4 years; 17-64 years) in the sick leave days sample and in the long-term absenteeism sample, respectively. According to the WHO categories, 1.8% were classified as underweight, 48.1% as normal weight, 35.5% as overweight, and 14.6% as obese, respectively in the sick leave days sample. In the sample with long-term absenteeism as outcome, 1.3% were classified as underweight, 41.3% as normal weight, 38.0% as overweight, and 19.4% as obese, respectively. Please see Table 1 for further details.

Table 1. Sample characteristics for individuals included in fixed effects regressions for the outcomes sick leave days and long-term absenteeism (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012, pooled)

	Sick leave days (n=48,865)		Long-term absenteeism (n=9,564)	
	N/Mean	%/SD	N/Mean	%/SD
Female	23,350	47.8%	4,658	48.7%
Age (in years)	41.9	11.2	45.4	10.4
Married, living together with spouse	30,016	61.4%	6,376	66.7%
Self-rated health (from 1= "very good" to 5 = "very bad")	2.5	0.8	2.8	0.9
Not severely disabled	45,644	93.4%	8,007	83.7%
Life satisfaction (from 0 = worst to 10 = best)	7.1	1.6	6.7	1.8
Underweight	867	1.8%	126	1.3%
Normal weight	23,524	48.1%	3,951	41.3%
Overweight	17,327	35.5%	3,632	38.0%
Obese	7,147	14.6%	1,855	19.4%

Comments: The explanatory variable sex was not included in FE regressions as independent variable, as it is time-constant (i.e., it usually did not vary within individuals over time). It was only used for descriptive purposes.

Regression analysis

Results of Poisson FE regressions with sick leave days as outcome measure are displayed in Table 2. Adjusting for potential confounders, regressions showed that transitions from normal weight to obesity were associated with an increase in the probability of sick leave days in women (incidence rate ratio (IRR): 1.27, 95% CI: 1.02-1.57), but not in men (IRR: 0.85, 95 % CI: 0.68-1.06). The corresponding interaction term (sex x obesity) reached statistical significance (p<.01).

Furthermore, sick leave days increased with the onset of disability, increases in age as well as decreases in self-rated health and life satisfaction in the total sample and in both sexes. The outcome measure was not significantly associated with marital status.

Results of conditional FE logistic regressions (outcome measure: long-term absenteeism) are described in Table 3. Adjusting for age, marital status, self-rated health, disability, and satisfaction with life, conditional FE logistic regressions revealed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95% CI: 1.08-1.85), but not in men (overweight, OR: 0.84, 95% CI: 0.65-1.09). Gender differences were significant (sex x overweight, p<.01).

The probability of long-term absenteeism increased with decreases in self-rated health and the onset of disability in the total sample and in both sexes. The probability of long-term absenteeism decreased with life satisfaction in the total sample and in men, but not in women. Contrarily, the probability of long-term absenteeism was positively associated with increases in age in the total sample and in women, but not in men.

Table 2. Results of Poisson FE regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of sick leave days (Incidence rate ratios were reported; 95% Confidence Interval (95% CI) in parentheses)

Independent variables	(1) Sick leave days – Total sample	(2) Sick leave days - Men	(3) Sick leave days - Women	(4) Sick leave days – Total sample with interaction term
Age	1.02*** (1.01 - 1.03)	1.02** (1.00 - 1.03)	1.02*** (1.01 - 1.03)	1.02*** (1.01 - 1.03)
Married, living together with spouse (Ref.: Others)	1.09+ (0.98 - 1.21)	1.05 (0.90 - 1.22)	1.13+ (0.98 - 1.31)	1.09+ (0.98 - 1.21)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.50*** (1.44 - 1.56)	1.54*** (1.46 - 1.64)	1.45*** (1.38 - 1.53)	1.50*** (1.44 - 1.56)
Severely disabled (Ref.: Not severely disabled)	2.28*** (1.98 - 2.62)	2.19*** (1.82 - 2.63)	2.37*** (1.93 - 2.92)	2.27*** (1.98 - 2.61)
Life satisfaction (from 0 = worst to 10 = best)	0.94*** (0.92 - 0.96)	0.94*** (0.91 - 0.96)	0.95*** (0.92 - 0.97)	0.94*** (0.92 - 0.96)
Underweight (Ref.: Normal weight)	0.95 (0.73 - 1.22)	0.74 (0.36 - 1.49)	1.00 (0.77 - 1.31)	0.74 (0.36 - 1.52)
Overweight (Ref.: Normal weight)	1.00 (0.91 - 1.10)	0.92 (0.81 - 1.04)	1.10 (0.96 - 1.25)	0.91 (0.80 - 1.03)
Obesity (Ref.: Normal weight)	1.03 (0.88 - 1.20)	0.85 (0.68 - 1.06)	1.27* (1.02 - 1.57)	0.83 (0.67 - 1.04)
Interaction term: Underweight x sex (Ref. male)				1.35 (0.63 - 2.89)
Interaction term: Overweight x sex (Ref. male)				1.22* (1.02 - 1.46)
Interaction term: Obesity x sex (Ref. male)				1.54** (1.13 - 2.08)
Observations	48,865	25,515	23,350	48,865
Number of Individuals	12,089	6,246	5,843	12,089

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Table 3. Results of conditional FE logistic regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of long-term absenteeism (Odds Ratios (OR) were reported; 95% Confidence Interval (95% CI) in parentheses)

Independent variables	(1) Long-term absenteeism – Total sample	(2) Long-term absenteeism - Men	(3) Long-term absenteeism - Women	(4) Long-term absenteeism – Total sample with interaction term
Age	1.02**	1.02^{+}	1.02*	1.02**
	(1.01 - 1.04)	(1.00 - 1.05)	(1.00 - 1.05)	(1.01 - 1.04)
Married, living together with spouse (Ref.: Others)	1.11	1.01	1.20	1.11
	(0.89 - 1.39)	(0.71 - 1.42)	(0.89 - 1.61)	(0.89 - 1.39)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.86***	1.95***	1.78***	1.86***
	(1.72 - 2.01)	(1.75 - 2.18)	(1.60 - 1.98)	(1.73 - 2.01)
Severely disabled (Ref.: Not severely disabled)	2.50***	2.38***	2.62***	2.49***
	(2.02 - 3.09)	(1.78 - 3.19)	(1.91 - 3.59)	(2.01 - 3.09)
Life satisfaction (from 0 = worst to 10 = best)	0.95**	0.92**	0.97	0.95**
	(0.91 - 0.98)	(0.87 - 0.98)	(0.92 - 1.03)	(0.91 - 0.99)
Underweight (Ref.: Normal weight)	0.57^{+}	0.29	0.68	0.30
	(0.30 - 1.08)	(0.06 - 1.35)	(0.34 - 1.36)	(0.07 - 1.36)
Overweight (Ref.: Normal weight)	1.08	0.84	1.41*	0.83
	(0.90 - 1.31)	(0.65 - 1.09)	(1.08 - 1.85)	(0.64 - 1.08)
Obesity (Ref.: Normal weight)	1.05	0.77	1.49^{+}	0.76
	(0.79 - 1.41)	(0.52 - 1.15)	(0.97 - 2.29)	(0.52 - 1.13)
Interaction term: Underweight x sex (Ref. male)				2.22
				(0.42 - 11.68)
Interaction term: Overweight x sex (Ref. male)				1.70**
				(1.17 - 2.47)
Interaction term: Obesity x sex (Ref. male)				1.95*
				(1.10 - 3.46)
Pseudo R^2	.08	.09	.08	.08
Observations	9,564	4,906	4,658	9,564
Number of Individuals	2,160	1,115	1,045	2,160

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Sensitivity analysis

Since the results might be affected by attrition bias, sensitivity analyses were conducted to test the robustness of our findings. We re-estimated our models on a sample including only those individuals who were surveyed in each of the six waves (27,592 observations with sick leave days as outcome measure; 6,139 observations with long-term absenteeism as outcome measure).

With regard to weight categories, the findings were similar to those found in our primary analyses in terms of significance and effect sizes (please see the supplementary table). In addition, regressions showed that transitions from normal weight to *overweight* were associated with an increase in the probability of sick leave days in women (IRR: 1.19, 95% CI: 1.01-1.41), but not in men (IRR: 0.91, 95% CI: 0.75-1.10; with significant interaction term, $p<.05$).

DISCUSSION

Based on a nationally representative sample (GSOEP), the aim of the present study was to examine the longitudinal association between obesity and sickness absence in women and in men. Knowledge regarding the longitudinal association between obesity and sickness absence (and the moderating role of sex) is important for implementing strategies to tackle this problem. Data were taken from 2002 to 2012. Adjusting for potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women, but not in men (with significant gender differences). Moreover, regression analysis showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women, but not in men.

According to previous work translating relative effect sizes (e.g., IRR and OR) into indices of effect size in public health studies,[28 29] the IRRs and the ORs found in our analyses are

classified as small. However, changes in weight from normal weight to overweight were associated with an increase in odds of long-term absenteeism of more than 40 percent among women.

The findings of this study generally correspond to those from prior research where overweight and obesity were suggested to be particularly related to long-term absenteeism; whereas no clear evidence for short-term absence was found.[7 8] In support of our results, existing studies found gender differences in the relationship between excess weight and absenteeism with a stronger association among women.[4 10 30]

As regards long-term absenteeism, our results are to some extent in line with the findings of a previous study conducted among Belgian workers.[10] The authors found a significant and positive association of both overweight and obesity and high sickness absence in women but not in men. The group of obese women in our study reached only marginal significance ($p<.10$) though. In contrast to our results, other studies reported no significant association between BMI class and long-term sickness absence after adjusting for potential confounders for both men and women.[9 31]

Similar to our findings regarding sick leave days, a study among middle aged employees in the city of Helsinki also observed a significantly increased risk of sickness absence for obese but not for overweight women, yet only for very short (less than 4 days) spells or spells longer than 14 days.[30] These findings disagree with the results from a London-based cohort study that reported significant associations between obesity and sick leave for both short and longer spells for both sexes.[11]

While higher rates of female sick leave have been reported in general, the significant interaction effect of sex and BMI on both sick leave days and long-term absenteeism may be further explained by unobserved psychological or psychosocial factors. Overweight and obesity have been proposed to exert a negative effect on one's body image and self-esteem, and this tends to be more pronounced in women, as they may be more affected by the slim

ideal compared to men.[32 33] In addition, perceived weight might play a role in the relationship between weight and sickness absence, insofar as negative weight perceptions may lead to higher levels of dissatisfaction and psychological distress, specifically in women.[34] Furthermore, overweight and obese women are more often targets of weight stigmatization, weight discrimination and prejudice (e.g., laziness, less self-control, work refusal), in particular regarding the workplace setting.[35-37] This may lead to higher risk of feelings of stress, thereby reducing job resources and increasing job strain. Consequently, they may be more likely to employ poor coping strategies (e.g., escaping or avoiding distressing situations) which could eventually result in withdrawal behaviors such as sick leave.[31 34]

Another explanation might be that medical consequences (e.g., musculoskeletal diseases, cardiovascular diseases or diabetes) of obesity differ to some extent between women and men [38 39]. Ultimately, these differences in morbidity might lead to differences in sickness absence between women and men. However, future research is needed to investigate this relationship.

Our results suggest a significant association between both the health–related and life satisfaction and illness-related sickness absence. This is in line with findings from previous studies reporting significant effects of self-rated health[10 19] and morbidity[11 40] on sickness absence. Similarly, a relationship between satisfaction with life and sick leave was referred to by previous research.[41 42] Concerning marital status, heterogeneous findings have been reported depending on its categorization, but generally marital status was related to sick leave with a trend towards lower sickness absence among married individuals.[43] This finding could not be confirmed in our study.

However, it should be stressed that direct comparisons of our results and those of previous studies are difficult because of differences in the measurement of (short- and long-term) sickness absence, differences in the study design (cross-sectional versus longitudinal), heterogeneity of the study population and the setting.

In total, results of this longitudinal study add to evidence from previous correlational studies, which suggest that obesity is associated with long-term absenteeism cross-sectionally [7 8]. Data came from a large nationally representative sample of German individuals (GSOEP). Individuals were observed over a long period (2002 to 2012). By using FE regressions, the problem of unobserved heterogeneity was diminished.[25]

Because in Germany sick pay is shortened after six weeks and not paid any longer by the employer but by a third-party payer (e.g. health insurance), and a different medical certificate has to be provided, it is expected that employees will quite accurately remember their sick leave spells. Hence, this indicator should be less prone to measurement error.[44] As regards sick leave days, we cannot dismiss the possibility of a recall bias. However, it has been shown that self-reported sick leave can be employed as a proxy measure when administrative data are not available.[45]

The self-rated BMI was used to classify obesity. As individuals tend to overestimate height and underestimate weight,[46] the BMI might be biased downwards. However, under the assumption that this bias is constant within individuals over time, this does not bias the FE estimates. In addition, a prior study investigating the predictive performance of different body weight measures on sickness absence found that self-reported BMI performed equally well as measured BMI.[47] Moreover, it is worth emphasizing that panel attrition might bias the FE estimates. However, it has been shown that panel attrition is quite low in the GSOEP.[15] In addition, the sensitivity analysis conducted indicates that attrition bias might be rather small. In addition, long-term absenteeism and sick leave days were quantified retrospectively. Hence, we cannot rule out that the outcome measures affect BMI change (endogeneity bias). Thus, future studies (e.g. based on panel instrumental variable procedures) are needed to overcome these problems.

To conclude, our findings highlight the longitudinal association between excess weight and workplace absenteeism. Effective interventions to treat excess weight might also be a promising strategy to reduce sickness absence in women.

CONTRIBUTORS

KCR, HHK and AH made substantial contributions to conception and design of the study, the analysis and interpretation of data and drafted the manuscript. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

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ETHICS APPROVAL

The German Council of Science and Humanities (Wissenschaftsrat) evaluated the German Socio-Economic Panel (GSOEP) at the Deutsches Institut für Wirtschaftsforschung, (DIW),

Berlin. The German Council of Science and Humanities approved the GSOEP. The GSOEP is in accordance with the Helsinki Declaration as revised in 2008.

Informed consent was obtained from all participants.

DATA SHARING STATEMENT

GSOEP data access must comply with high security standards for maintaining confidentiality and protecting personal privacy. The data are also subject to regulations limiting their use to scientific purposes; that is, they are only made available to the scientific community (in German language only). After conclusion of a data distribution contract with DIW Berlin, the data of every new wave will be available on request either via personalized encrypted download or via certified mail on a DVD. Please see for further information: https://www.diw.de/en/diw_02.c.238237.en/conditions.html.

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Supplementary Table. Results of Poisson and conditional FE logistic regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of sick leave days (column 1 to 4) and long-term absenteeism (column 5 to 8)

Independent variables	(1) Sick Leave Days – Total sample	(2) Sick Leave Days – Men	(3) Sick Leave Days – Women	(4) Sick Leave Days – Total sample with interaction term	(5) Long-term absenteeism – Total sample	(6) Long-term absenteeism – Men	(7) Long-term absenteeism – Women	(8) Long-term absenteeism – Total sample with interaction term
Age	1.03***	1.02**	1.03***	1.03***	1.03**	1.03*	1.03*	1.03***
	(1.02 - 1.04)	(1.01 - 1.04)	(1.01 - 1.04)	(1.02 - 1.04)	(1.01 - 1.05)	(1.01 - 1.06)	(1.00 - 1.06)	(1.01 - 1.05)
Married, living together with spouse (Ref.: Others)	1.09	1.08	1.09	1.08	1.11	1.04	1.15	1.10
	(0.94 - 1.26)	(0.86 - 1.36)	(0.89 - 1.32)	(0.94 - 1.26)	(0.83 - 1.48)	(0.66 - 1.63)	(0.79 - 1.68)	(0.83 - 1.47)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.52***	1.61***	1.43***	1.51***	1.82***	1.96***	1.70***	1.82***
	(1.44 - 1.60)	(1.49 - 1.75)	(1.33 - 1.53)	(1.44 - 1.60)	(1.65 - 2.01)	(1.69 - 2.27)	(1.48 - 1.95)	(1.65 - 2.01)
Severely disabled (Ref.: Not severely disabled)	2.35***	2.17***	2.55***	2.33***	2.65***	2.12***	3.36***	2.62***
	(1.97 - 2.80)	(1.71 - 2.74)	(1.96 - 3.32)	(1.96 - 2.79)	(2.03 - 3.46)	(1.47 - 3.04)	(2.26 - 4.99)	(2.01 - 3.42)
Life satisfaction (from 0 = worst to 10 = best)	0.92***	0.92***	0.92***	0.92***	0.91***	0.90**	0.93*	0.91***
	(0.89 - 0.95)	(0.88 - 0.96)	(0.89 - 0.96)	(0.89 - 0.95)	(0.87 - 0.96)	(0.83 - 0.97)	(0.87 - 1.00)	(0.87 - 0.96)
Underweight (Ref.: Normal weight)	1.16	1.14	1.16	1.16	1.12	0.64	1.23	0.62
	(0.82 - 1.65)	(0.41 - 3.17)	(0.80 - 1.67)	(0.40 - 3.36)	(0.49 - 2.55)	(0.08 - 5.04)	(0.50 - 3.00)	(0.08 - 4.98)
Overweight (Ref.: Normal weight)	1.05	0.91	1.19*	0.91	1.21	0.82	1.72**	0.82
	(0.92 - 1.19)	(0.75 - 1.10)	(1.01 - 1.41)	(0.75 - 1.09)	(0.94 - 1.55)	(0.57 - 1.18)	(1.21 - 2.44)	(0.58 - 1.17)
Obesity (Ref.: Normal weight)	1.12	0.90	1.39*	0.89	1.11	0.74	1.62+	0.73
	(0.92 - 1.36)	(0.68 - 1.21)	(1.06 - 1.83)	(0.67 - 1.19)	(0.76 - 1.63)	(0.43 - 1.25)	(0.92 - 2.86)	(0.44 - 1.23)
Interaction term: Underweight x sex (Ref. male)				1.00				2.02
				(0.32 - 3.08)				(0.21 - 19.60)
Interaction term: Overweight x sex (Ref. male)				1.32*				2.10**
				(1.03 - 1.69)				(1.28 - 3.45)
Interaction term: Obesity x sex (Ref. male)				1.56*				2.21*
				(1.05 - 2.30)				(1.04 - 4.71)
Pseudo R^2					.08	.09	.08	.09
Observations	27,592	13,931	13,661	27,592	6,139	3,006	3,133	6,139
Number of Individuals	5,446	2,681	2,765	5,446	1,181	573	608	1,181

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10; As regards Poisson FE regressions (column 1 to 4): Incidence rate ratios were reported; 95% Confidence Interval (95% CI) in parentheses; As regards conditional FE logistic regressions (column 5 to 8): Odds Ratios (OR) were reported; 95% CI in parentheses

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Obesity and sickness absence – Results from a longitudinal nationally representative sample from Germany

Running head: Obesity and sick leave days

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ABSTRACT

Objectives: The current study aimed at investigating the longitudinal association between obesity and sickness absence in women and men in Germany.

Methods: Data were derived from the German Socio-Economic Panel (GSOEP), which is a nationally representative, longitudinal study of private households in Germany. We draw on data from 2002 through 2012. Information on self-rated BMI has been collected every second wave since 2002. Sick leave days (total number of working days missed due to illness in the past calendar year) and sick from work for more than six weeks in the preceding 12 months (yes; no) were used as outcome measures. Fixed effects (FE) regression models were used for the total sample and stratified by sex. Gender differences were examined using interaction terms (sex x weight category).

Results: Controlling for several potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women (incidence rate ratio (IRR): 1.27, 95% CI: 1.02-1.57) but not in men (IRR: 0.85, 95 % CI: 0.68-1.06) – with significant gender differences (sex x obesity, p<.01). Moreover, conditional FE logistic regressions showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95% CI: 1.08-1.85) but not in men (overweight, OR: 0.84, 95% CI: 0.65-1.09). Gender differences were significant (sex x overweight, p<.01).

Conclusions: Our findings stress the longitudinal association between excess weight and increased likelihood of sick leave days as well as long-term absenteeism in women.

Keywords: long-term absenteeism; sick leave days; body-mass-index; excess weight; longitudinal studies

Strengths and limitations of this study

- Data came from a large nationally representative sample of German individuals.
- Panel regression models were used, diminishing the problem of unobserved heterogeneity.
- The possibility of reverse causality cannot be dismissed.
- The self-rated BMI was used to classify obesity.

INTRODUCTION

Obesity remains a major health concern in Western societies [1]. Behind the Americas, Europe ranks second regarding the proportion of overweight (25 kg/m² ≤ BMI < 30 kg/m²) or obese (BMI ≥ 30 kg/m²) people, according to the WHO statistics. The share of men and women being 18 years and over having a body mass index (BMI) ≥ 25 kg/m² amounts to 59.1% and 44.7%, respectively, and in the EU-28. For Germany, the prevalence of adult obesity has recently been estimated to range between 16.5%-23.9% in women and 17.3%-23.3% in men.[2 3] Obesity and its related adverse health effects pose a considerable burden to the healthcare system because of both its direct costs incurred by increased health service utilization and indirect costs arising from reduced or lost workforce productivity.[4 5] Several studies found that indirect costs of overweight and obesity make up the majority (51%-59%) of total costs, thus exceeding direct costs.[6] Unsurprisingly, the impact of obesity on the workplace in terms of absence from work due to excess weight related illnesses or other factors continues to be of primary interest to health policy makers and employers.

The association between obesity and sickness absence has been well documented cross-sectionally. Studies found a tendency for obese individuals to have a higher number of sick leave events and also have longer spells of individual sick leave compared to their normal-weight counterparts.[4 7 8] As regards pre-obesity / overweight, inconsistent results have been reported in literature for the association with sickness absence. While some studies found evidence of an elevated risk of sick leave for pre-obese subjects, others reported no significant association when compared to normal-weight subjects.[7 8] However, in general, there tended to be a positive relationship between higher levels of BMI and sick leave, although available results pertaining to short-term spells were less clear, which may be due to discrepant definitions of short-term sick leave.[7-9] Findings further suggested gender differences regarding the association between sickness absence and both pre-obesity and obesity. Women showed higher rates of sickness absence and also stronger associations were observed for female employees.[4 10 11]

Many studies that have been conducted so far employ cross-sectional designs which do not allow drawing conclusions about causal mechanisms. So far there is yet limited longitudinal research investigating the association between excess weight and sickness absence. While most of the *longitudinal* studies have been carried out in the US or the Scandinavian countries, evidence is still lacking for Germany. Therefore, the aim of this study was to assess the association between obesity and sickness absence using a representative sample of the German labor force in a longitudinal setting.

STUDY POPULATION AND METHODS

Sample

We used data from the German Socio-Economic Panel Study (GSOEP), a representative longitudinal survey of the German population conducted on an annual basis since 1984.[12] The GSOEP is located at the German Institute for Economic Research (DIW Berlin). It is a household panel like the Panel Study of Income Dynamics in the US (PSID) or the British Household Panel Study (BHPS). Every year, approximately 11,000 households and more than 20,000 individuals were interviewed. All adult household members (aged 17 and over) are interviewed. Topics include, for example, domain satisfaction (e.g., satisfaction with leisure time), health, or occupational status. Very high re-interview response rates were observed in the GSOEP.[13] In addition, it was found that survey attrition is low in the GSOEP (in most years and sub-samples, attrition was less than 10%[14]).[15] Further details regarding the sampling frame as well as the survey design of the GSOEP are given elsewhere.[16]

In the current study, the analyses were based on data from six waves (2002-2012, bi-annually), because BMI was assessed only bi-annually. We restricted our sample to individuals aged 17 to 65 years who were in the labor force and employed at all waves. Thus, while regression analysis with sick leave days as outcome measure is based on 48,865

observations, the regression analysis with long-term absenteeism as outcome measure is based on 9,564 observations.

All information is based on self-reports obtained by respondents.

Dependent variables

Our dependent variables were sick leave days and long-term absenteeism. Sick leave days is operationalized as the total number of working days missed due to illness in the past calendar year (*"How many days were you not able to work in 20XX because of illness? Please state all the days, not just those for which you had an official note from your doctor."*). Individuals reported the frequency of days of absence ("none", "a total of X days"). Long-term absenteeism is based on a question that assessed whether a person was sick from work for more than six weeks at one time in the previous calendar year ("*Were you sick from work for more than six weeks at one time last year?*"). Employees who reported not being sick from work for more than 6 weeks were coded as zero, while employees with a positive answer ("yes, once" and "yes, several times") were coded as ones.

Independent variables

Body mass index (BMI) was based on self-reported values of height and weight and calculated as weight divided by squared height (kg/m²). We categorized BMI into four groups according to the WHO classification as underweight (BMI ≤ 18.5 kg/m²), normal weight (18.5 kg/m² ≤ BMI < 25 kg/m²), pre-obese/overweight (25 kg/m² ≤ BMI < 30 kg/m²), and obese (BMI ≥ 30 kg/m²).[17 18]

Several sociodemographic, health-related and subjective well-being factors that have been identified by prior research to be associated with both excess weight and productivity loss, or proposed to influence the relationship between obesity and sickness absence were entered as potential confounders in the analyses.[9 10 19 20] As regards sociodemographic characteristics, we considered age, and marital status, the latter being dichotomized with married, living together coded as one and zero otherwise (i.e., married, but living separated

from spouse; divorced; widowed; single are coded as zero). Concerning health-related and subjective well-being factors, we included *subjective* health, which was based on individuals' self-rated health (5-point Likert scale: 1="bad" and 5="very good") and disability assessed by a single item asking whether they were "legally classified as handicapped or capable of gainful employment only to a reduced extent due to medical reasons" (no/yes). The disability variable served as a proxy measure for *objective* morbidity.[21 22] In accordance with prior research [23], the continuous variable satisfaction with life evaluated by the question "How satisfied are you with your life, all things considered?" (11-point rating scale ranging from 0 "completely dissatisfied" to 10 "completely satisfied") was included. Moreover, the time-invariant variable sex was used for descriptive purposes.

Statistical analysis

We used fixed effects (FE) regression models to estimate the longitudinal association between excess weight and sickness absence. As the sick leave days is a non-negative integer number (count data), the Poisson model was chosen. To analyze the longitudinal association between excess weight and the binary outcome long-term absenteeism, we employed a conditional logit fixed effects model, which is a common method for panel data analysis. FE models permit correlations between unobserved time-invariant variables (e.g. genetic disposition) and predictors, yielding consistent estimates (when the strict exogeneity assumption holds).[24]

Our main goal was to provide consistent estimates under very weak assumptions. [24 25] Therefore, FE regressions were used. The FE specification was also preferred based on the Hausman test.[26] For example, the Hausman test statistic was $X^2=838.31$, $p<.001$ (with sick leave days as outcome measure).

FE models solely exploit changes within units (here: participants) over time ("within variation"). Consequently, the effect of variables that are time-constant (e.g., sex) cannot be

estimated by FE regressions.[24] Yet, FE regressions do allow for interactions between time-invariant and time-varying predictors.[25]

Therefore, we first estimated the model for the total sample (implicitly controlling for the time-invariant variable sex). In order to explore the potential gender-related differential association with obesity, we then conducted the analysis separately for men and women. We also estimated the model, including an interaction term between BMI class and sex, which allows us to further test for and measure significant differences between male and female employees. This procedure was similar for both the FE Poisson model and the conditional logit FE model.

Models were tested for multicollinearity between predictor variables using the variance inflation factor. Yet we could not detect a collinearity problem (i.e., all variance inflation factors were below 2). For the FE Poisson regressions, cluster robust standard errors were used.[27]

A P value less than 0.05 was deemed statistically significant. All analyses were performed using Stata 14.2 (Stata Corp., College Station, Texas).

Patient and Public Involvement

No patients were directly involved in the development of the research question, selection of the outcome measures, design and implementation of the study, or interpretation of the results.

RESULTS

Sample characteristics

Pooled sample characteristics for individuals included in FE regression analysis with sick leave days (column 1) and long-term absenteeism (column 2) as outcome variables are described in Table 1. Total observations differ among the models, as there was a varying

number of changes over time in these outcome measures (intraindividual changes in sick leave days vs. intraindividual changes in long-term absenteeism). Thus, while the Poisson FE regression (with sick leave days as outcome measure) is based on 48,865 observations, the conditional FE logistic regression (with long-term absenteeism as outcome measure) is based on 9,564 observations. It might be the case that individuals with within-variation on sick leave days also provide within-information on long-term absenteeism. However, it is not necessarily the case.

In total (Table 1, columns 1 and 2), nearly one-half were female (47.8% in the sample with sick leave days as outcome, 48.7% in the sample with long-term absenteeism as outcome). The mean age was 41.9 (±11.2 years; 17-64 years) and 45.4 (±10.4 years; 17-64 years) in the sick leave days sample and in the long-term absenteeism sample, respectively. According to the WHO categories, 1.8% were classified as underweight, 48.1% as normal weight, 35.5% as overweight, and 14.6% as obese, respectively in the sick leave days sample. In the sample with long-term absenteeism as outcome, 1.3% were classified as underweight, 41.3% as normal weight, 38.0% as overweight, and 19.4% as obese, respectively. Please see Table 1 for further details.

Table 1. Sample characteristics for individuals included in fixed effects regressions for the outcomes sick leave days and long-term absenteeism (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012, pooled)

	Sick leave days (n=48,865)		Long-term absenteeism (n=9,564)	
	N/Mean	%/SD	N/Mean	%/SD
Female	23,350	47.8%	4,658	48.7%
Age (in years)	41.9	11.2	45.4	10.4
Married, living together with spouse	30,016	61.4%	6,376	66.7%
Self-rated health (from 1= "very good" to 5 = "very bad")	2.5	0.8	2.8	0.9
Not severely disabled	45,644	93.4%	8,007	83.7%
Life satisfaction (from 0 = worst to 10 = best)	7.1	1.6	6.7	1.8
Underweight	867	1.8%	126	1.3%
Normal weight	23,524	48.1%	3,951	41.3%
Overweight	17,327	35.5%	3,632	38.0%
Obese	7,147	14.6%	1,855	19.4%

Comments: The explanatory variable sex was not included in FE regressions as independent variable, as it is time-constant (i.e., it usually did not vary within individuals over time). It was only used for descriptive purposes.

Regression analysis

Results of Poisson FE regressions with sick leave days as outcome measure are displayed in Table 2. Adjusting for potential confounders, regressions showed that transitions from normal weight to obesity were associated with an increase in the probability of sick leave days in women (incidence rate ratio (IRR): 1.27, 95% CI: 1.02-1.57), but not in men (IRR: 0.85, 95 % CI: 0.68-1.06). The corresponding interaction term (sex x obesity) reached statistical significance (p<.01).

Furthermore, sick leave days increased with the onset of disability, increases in age as well as decreases in self-rated health and life satisfaction in the total sample and in both sexes. The outcome measure was not significantly associated with marital status.

Results of conditional FE logistic regressions (outcome measure: long-term absenteeism) are described in Table 3. Adjusting for age, marital status, self-rated health, disability, and satisfaction with life, conditional FE logistic regressions revealed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women (overweight, OR: 1.41, 95% CI: 1.08-1.85), but not in men (overweight, OR: 0.84, 95% CI: 0.65-1.09). Gender differences were significant (sex x overweight, p<.01).

The probability of long-term absenteeism increased with decreases in self-rated health and the onset of disability in the total sample and in both sexes. The probability of long-term absenteeism decreased with life satisfaction in the total sample and in men, but not in women. Contrarily, the probability of long-term absenteeism was positively associated with increases in age in the total sample and in women, but not in men.

Table 2. Results of Poisson FE regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of sick leave days (Incidence rate ratios were reported; 95% Confidence Interval (95% CI) in parentheses)

Independent variables	(1) Sick leave days – Total sample	(2) Sick leave days - Men	(3) Sick leave days - Women	(4) Sick leave days – Total sample with interaction term
Age	1.02*** (1.01 - 1.03)	1.02** (1.00 - 1.03)	1.02*** (1.01 - 1.03)	1.02*** (1.01 - 1.03)
Married, living together with spouse (Ref.: Others)	1.09+ (0.98 - 1.21)	1.05 (0.90 - 1.22)	1.13+ (0.98 - 1.31)	1.09+ (0.98 - 1.21)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.50*** (1.44 - 1.56)	1.54*** (1.46 - 1.64)	1.45*** (1.38 - 1.53)	1.50*** (1.44 - 1.56)
Severely disabled (Ref.: Not severely disabled)	2.28*** (1.98 - 2.62)	2.19*** (1.82 - 2.63)	2.37*** (1.93 - 2.92)	2.27*** (1.98 - 2.61)
Life satisfaction (from 0 = worst to 10 = best)	0.94*** (0.92 - 0.96)	0.94*** (0.91 - 0.96)	0.95*** (0.92 - 0.97)	0.94*** (0.92 - 0.96)
Underweight (Ref.: Normal weight)	0.95 (0.73 - 1.22)	0.74 (0.36 - 1.49)	1.00 (0.77 - 1.31)	0.74 (0.36 - 1.52)
Overweight (Ref.: Normal weight)	1.00 (0.91 - 1.10)	0.92 (0.81 - 1.04)	1.10 (0.96 - 1.25)	0.91 (0.80 - 1.03)
Obesity (Ref.: Normal weight)	1.03 (0.88 - 1.20)	0.85 (0.68 - 1.06)	1.27* (1.02 - 1.57)	0.83 (0.67 - 1.04)
Interaction term: Underweight x sex (Ref. male)				1.35 (0.63 - 2.89)
Interaction term: Overweight x sex (Ref. male)				1.22* (1.02 - 1.46)
Interaction term: Obesity x sex (Ref. male)				1.54** (1.13 - 2.08)
Observations	48,865	25,515	23,350	48,865
Number of Individuals	12,089	6,246	5,843	12,089

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10; Observations with missing values were dropped (listwise deletion)

Table 3. Results of conditional FE logistic regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of long-term absenteeism (Odds Ratios (OR) were reported; 95% Confidence Interval (95% CI) in parentheses)

Independent variables	(1) Long-term absenteeism – Total sample	(2) Long-term absenteeism - Men	(3) Long-term absenteeism - Women	(4) Long-term absenteeism – Total sample with interaction term
Age	1.02**	1.02^{+}	1.02*	1.02**
	(1.01 - 1.04)	(1.00 - 1.05)	(1.00 - 1.05)	(1.01 - 1.04)
Married, living together with spouse (Ref.: Others)	1.11	1.01	1.20	1.11
	(0.89 - 1.39)	(0.71 - 1.42)	(0.89 - 1.61)	(0.89 - 1.39)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.86***	1.95***	1.78***	1.86***
	(1.72 - 2.01)	(1.75 - 2.18)	(1.60 - 1.98)	(1.73 - 2.01)
Severely disabled (Ref.: Not severely disabled)	2.50***	2.38***	2.62***	2.49***
	(2.02 - 3.09)	(1.78 - 3.19)	(1.91 - 3.59)	(2.01 - 3.09)
Life satisfaction (from 0 = worst to 10 = best)	0.95**	0.92**	0.97	0.95**
	(0.91 - 0.98)	(0.87 - 0.98)	(0.92 - 1.03)	(0.91 - 0.99)
Underweight (Ref.: Normal weight)	0.57^{+}	0.29	0.68	0.30
	(0.30 - 1.08)	(0.06 - 1.35)	(0.34 - 1.36)	(0.07 - 1.36)
Overweight (Ref.: Normal weight)	1.08	0.84	1.41*	0.83
	(0.90 - 1.31)	(0.65 - 1.09)	(1.08 - 1.85)	(0.64 - 1.08)
Obesity (Ref.: Normal weight)	1.05	0.77	1.49^{+}	0.76
	(0.79 - 1.41)	(0.52 - 1.15)	(0.97 - 2.29)	(0.52 - 1.13)
Interaction term: Underweight x sex (Ref. male)				2.22
				(0.42 - 11.68)
Interaction term: Overweight x sex (Ref. male)				1.70**
				(1.17 - 2.47)
Interaction term: Obesity x sex (Ref. male)				1.95*
				(1.10 - 3.46)
Pseudo R^2	.08	.09	.08	.08
Observations	9,564	4,906	4,658	9,564
Number of Individuals	2,160	1,115	1,045	2,160

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10; Observations with missing values were dropped (listwise deletion)

Sensitivity analysis

Since the results might be affected by attrition bias, sensitivity analyses were conducted to test the robustness of our findings. We re-estimated our models on a sample including only those individuals who were surveyed in each of the six waves (27,592 observations with sick leave days as outcome measure; 6,139 observations with long-term absenteeism as outcome measure).

With regard to weight categories, the findings were similar to those found in our primary analyses in terms of significance and effect sizes (please see the supplementary table). In addition, regressions showed that transitions from normal weight to *overweight* were associated with an increase in the probability of sick leave days in women (IRR: 1.19, 95% CI: 1.01-1.41), but not in men (IRR: 0.91, 95% CI: 0.75-1.10; with significant interaction term, $p<.05$).

DISCUSSION

Based on a nationally representative sample (GSOEP), the aim of the present study was to examine the longitudinal association between obesity and sickness absence in women and in men. Knowledge regarding the longitudinal association between obesity and sickness absence (and the moderating role of sex) is important for implementing strategies to tackle this problem. Data were taken from 2002 to 2012. Adjusting for potential confounders, Poisson FE regression analysis showed that transitions from normal weight to obesity were associated with an increase in sick leave days in women, but not in men (with significant gender differences). Moreover, regression analysis showed that transitions from normal weight to overweight were associated with an increase in the probability of long-term absenteeism in women, but not in men.

According to previous work translating relative effect sizes (e.g., IRR and OR) into indices of effect size in public health studies,[28 29] the IRRs and the ORs found in our analyses are

classified as small. However, changes in weight from normal weight to overweight were associated with an increase in odds of long-term absenteeism of more than 40 percent among women.

The findings of this study generally correspond to those from prior research where overweight and obesity were suggested to be particularly related to long-term absenteeism; whereas no clear evidence for short-term absence was found.[7 8] In support of our results, existing studies found gender differences in the relationship between excess weight and absenteeism with a stronger association among women.[4 10 30]

As regards long-term absenteeism, our results are to some extent in line with the findings of a previous study conducted among Belgian workers.[10] The authors found a significant and positive association of both overweight and obesity and high sickness absence in women but not in men. The group of obese women in our study reached only marginal significance ($p<.10$) though. In contrast to our results, other studies reported no significant association between BMI class and long-term sickness absence after adjusting for potential confounders for both men and women.[9 31]

Similar to our findings regarding sick leave days, a study among middle aged employees in the city of Helsinki also observed a significantly increased risk of sickness absence for obese but not for overweight women, yet only for very short (less than 4 days) spells or spells longer than 14 days.[30] These findings disagree with the results from a London-based cohort study that reported significant associations between obesity and sick leave for both short and longer spells for both sexes.[11]

While higher rates of female sick leave have been reported in general, the significant interaction effect of sex and BMI on both sick leave days and long-term absenteeism may be further explained by unobserved psychological or psychosocial factors. Overweight and obesity have been proposed to exert a negative effect on one's body image and self-esteem, and this tends to be more pronounced in women, as they may be more affected by the slim

ideal compared to men.[32 33] In addition, perceived weight might play a role in the relationship between weight and sickness absence, insofar as negative weight perceptions may lead to higher levels of dissatisfaction and psychological distress, specifically in women.[34] Furthermore, overweight and obese women are more often targets of weight stigmatization, weight discrimination and prejudice (e.g., laziness, less self-control, work refusal), in particular regarding the workplace setting.[35-37] This may lead to higher risk of feelings of stress, thereby reducing job resources and increasing job strain. Consequently, they may be more likely to employ poor coping strategies (e.g., escaping or avoiding distressing situations) which could eventually result in withdrawal behaviors such as sick leave.[31 34]

Another explanation might be that medical consequences (e.g., musculoskeletal diseases, cardiovascular diseases or diabetes) of obesity differ to some extent between women and men [38 39]. Ultimately, these differences in morbidity might lead to differences in sickness absence between women and men. However, future research is needed to investigate this relationship.

Our results suggest a significant association between both the health–related and life satisfaction and illness-related sickness absence. This is in line with findings from previous studies reporting significant effects of self-rated health[10 19] and morbidity[11 40] on sickness absence. Similarly, a relationship between satisfaction with life and sick leave was referred to by previous research.[41 42] Concerning marital status, heterogeneous findings have been reported depending on its categorization, but generally marital status was related to sick leave with a trend towards lower sickness absence among married individuals.[43] This finding could not be confirmed in our study.

However, it should be stressed that direct comparisons of our results and those of previous studies are difficult because of differences in the measurement of (short- and long-term) sickness absence, differences in the study design (cross-sectional versus longitudinal), heterogeneity of the study population and the setting.

In total, results of this longitudinal study add to evidence from previous correlational studies, which suggest that obesity is associated with long-term absenteeism cross-sectionally [7 8]. Data came from a large nationally representative sample of German individuals (GSOEP). Individuals were observed over a long period (2002 to 2012). By using FE regressions, the problem of unobserved heterogeneity was diminished.[25]

Because in Germany sick pay is shortened after six weeks and not paid any longer by the employer but by a third-party payer (e.g. health insurance), and a different medical certificate has to be provided, it is expected that employees will quite accurately remember their sick leave spells. Hence, this indicator should be less prone to measurement error.[44] As regards sick leave days, we cannot dismiss the possibility of a recall bias. However, it has been shown that self-reported sick leave can be employed as a proxy measure when administrative data are not available.[45]

The self-rated BMI was used to classify obesity. As individuals tend to overestimate height and underestimate weight,[46] the BMI might be biased downwards. However, under the assumption that this bias is constant within individuals over time, this does not bias the FE estimates. In addition, a prior study investigating the predictive performance of different body weight measures on sickness absence found that self-reported BMI performed equally well as measured BMI.[47] Moreover, it is worth emphasizing that panel attrition might bias the FE estimates. However, it has been shown that panel attrition is quite low in the GSOEP.[15] In addition, the sensitivity analysis conducted indicates that attrition bias might be rather small. In addition, long-term absenteeism and sick leave days were quantified retrospectively. Hence, we cannot rule out that the outcome measures affect BMI change (endogeneity bias). Thus, future studies (e.g. based on panel instrumental variable procedures) are needed to overcome these problems.

As regards generalizability, it should be noted that results of FE regressions are often interpreted as average treatment effect on the treated (ATET[48]). Consequently, our findings

are generalizable to individuals in the population who change their sickness absence behavior in Germany over time. As already argued by Brüderl and Ludwig[48] this is not a limitation of FE estimates. It simply reflects the fact that only a small proportion of individuals in the population changed their sickness absence behavior.

To conclude, our findings highlight the longitudinal association between excess weight and workplace absenteeism. Effective interventions to treat excess weight might also be a promising strategy to reduce sickness absence in women.

CONTRIBUTORS

KCR, HHK and AH made substantial contributions to conception and design of the study, the analysis and interpretation of data and drafted the manuscript. All authors read and approved the final manuscript.

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COMPETING INTERESTS

None declared.

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ETHICS APPROVAL

The German Council of Science and Humanities (Wissenschaftsrat) evaluated the German Socio-Economic Panel (GSOEP) at the Deutsches Institut für Wirtschaftsforschung, (DIW), Berlin. The German Council of Science and Humanities approved the GSOEP. The GSOEP is in accordance with the Helsinki Declaration as revised in 2008.

Informed consent was obtained from all participants.

DATA SHARING STATEMENT

GSOEP data access must comply with high security standards for maintaining confidentiality and protecting personal privacy. The data are also subject to regulations limiting their use to scientific purposes; that is, they are only made available to the scientific community (in German language only). After conclusion of a data distribution contract with DIW Berlin, the data of every new wave will be available on request either via personalized encrypted download or via certified mail on a DVD. Please see for further information: https://www.diw.de/en/diw_02.c.238237.en/conditions.html.

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Supplementary Table. Results of Poisson and conditional FE logistic regressions (Wave 2002, wave 2004, wave 2006, wave 2008, wave 2010 and wave 2012). Determinants of sick leave days (column 1 to 4) and long-term absenteeism (column 5 to 8)

Independent variables	(1) Sick Leave Days – Total sample	(2) Sick Leave Days – Men	(3) Sick Leave Days – Women	(4) Sick Leave Days – Total sample with interaction term	(5) Long-term absenteeism – Total sample	(6) Long-term absenteeism – Men	(7) Long-term absenteeism – Women	(8) Long-term absenteeism – Total sample with interaction term
Age	1.03***	1.02**	1.03***	1.03***	1.03**	1.03*	1.03*	1.03***
	(1.02 - 1.04)	(1.01 - 1.04)	(1.01 - 1.04)	(1.02 - 1.04)	(1.01 - 1.05)	(1.01 - 1.06)	(1.00 - 1.06)	(1.01 - 1.05)
Married, living together with spouse (Ref.: Others)	1.09	1.08	1.09	1.08	1.11	1.04	1.15	1.10
	(0.94 - 1.26)	(0.86 - 1.36)	(0.89 - 1.32)	(0.94 - 1.26)	(0.83 - 1.48)	(0.66 - 1.63)	(0.79 - 1.68)	(0.83 - 1.47)
Self-rated health (from 1 = 'very good' to 5 = 'bad')	1.52***	1.61***	1.43***	1.51***	1.82***	1.96***	1.70***	1.82***
	(1.44 - 1.60)	(1.49 - 1.75)	(1.33 - 1.53)	(1.44 - 1.60)	(1.65 - 2.01)	(1.69 - 2.27)	(1.48 - 1.95)	(1.65 - 2.01)
Severely disabled (Ref.: Not severely disabled)	2.35***	2.17***	2.55***	2.33***	2.65***	2.12***	3.36***	2.62***
	(1.97 - 2.80)	(1.71 - 2.74)	(1.96 - 3.32)	(1.96 - 2.79)	(2.03 - 3.46)	(1.47 - 3.04)	(2.26 - 4.99)	(2.01 - 3.42)
Life satisfaction (from 0 = worst to 10 = best)	0.92***	0.92***	0.92***	0.92***	0.91***	0.90**	0.93*	0.91***
	(0.89 - 0.95)	(0.88 - 0.96)	(0.89 - 0.96)	(0.89 - 0.95)	(0.87 - 0.96)	(0.83 - 0.97)	(0.87 - 1.00)	(0.87 - 0.96)
Underweight (Ref.: Normal weight)	1.16	1.14	1.16	1.16	1.12	0.64	1.23	0.62
	(0.82 - 1.65)	(0.41 - 3.17)	(0.80 - 1.67)	(0.40 - 3.36)	(0.49 - 2.55)	(0.08 - 5.04)	(0.50 - 3.00)	(0.08 - 4.98)
Overweight (Ref.: Normal weight)	1.05	0.91	1.19*	0.91	1.21	0.82	1.72**	0.82
	(0.92 - 1.19)	(0.75 - 1.10)	(1.01 - 1.41)	(0.75 - 1.09)	(0.94 - 1.55)	(0.57 - 1.18)	(1.21 - 2.44)	(0.58 - 1.17)
Obesity (Ref.: Normal weight)	1.12	0.90	1.39*	0.89	1.11	0.74	1.62+	0.73
	(0.92 - 1.36)	(0.68 - 1.21)	(1.06 - 1.83)	(0.67 - 1.19)	(0.76 - 1.63)	(0.43 - 1.25)	(0.92 - 2.86)	(0.44 - 1.23)
Interaction term: Underweight x sex (Ref. male)				1.00				2.02
				(0.32 - 3.08)				(0.21 - 19.60)
Interaction term: Overweight x sex (Ref. male)				1.32*				2.10**
				(1.03 - 1.69)				(1.28 - 3.45)
Interaction term: Obesity x sex (Ref. male)				1.56*				2.21*
				(1.05 - 2.30)				(1.04 - 4.71)
Pseudo R^2					.08	.09	.08	.09
Observations	27,592	13,931	13,661	27,592	6,139	3,006	3,133	6,139
Number of Individuals	5,446	2,681	2,765	5,446	1,181	573	608	1,181

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10; As regards Poisson FE regressions (column 1 to 4): Incidence rate ratios were reported; 95% Confidence Interval (95% CI) in parentheses; As regards conditional FE logistic regressions (column 5 to 8): Odds Ratios (OR) were reported; 95% CI in parentheses

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	12-13
		(*d*) If applicable, explain how loss to follow-up was addressed	14
		(*e*) Describe any sensitivity analyses	14
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	12-13
		(c) Summarise follow-up time (eg, average and total amount)	5-6
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	10

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	12-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.